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ABSTRACT

Computer simulation enables us to construct and test the dynamics of complex physical and biological systems as well as a wide variety of social processes and problems. This bibliography contains abstracts and annotations of over 150 publications of the Rand Corporation on the theory, design, and use of computer simulation. A first section lists brief annotations and code numbers for each reference under appropriate subject headings, while the second section offers an index of the documents by author. The major portion of the bibliography consists of abstracts of the publications and includes the code number, title, author, and date for each entry. Ordering and price information are appended. (Author/SH)

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A BIBLIOGRAPHY OF

Selected Rand Publications

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COMPUTER SIMULATION

Computer simulation enables us to construct and test the dynamics of complex physical and biological systems as well as a wide variety of social processes and problems. This bibliography contains abstracts of Rand publications on the theory, design, and use of computer simulation.

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P-4390 Prevention of Hypokalemic Cardiac Arrhythmias Associated with Cardiopulmonary Bypass and Hemodilution.

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RM-5883-PR Digital Computer Simulation: Computer Programming Languages.
P-3314 Introduction to the SIMSCRIPT II Programming Language.
P-3348 Development of New Digital Simulation Languages.
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P-3861 Simulation Programming Using SIMSCRIPT II.

KNOLLMEYER, L. E.
RM-6086-PR The Pilot Training Study: A Cost-Estimating Model for Advanced Pilot Training.

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RM-5272-PR A Mathematical Model for Post-Irradiation Hematopoietic Recovery.

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RM-6230-RC A Water Quality Simulation Model for Well-Mixed Estuaries and Coastal Seas: Volume I, Principles of Computation.
P-4163 Environmental Simulation Tool in a Marine Waste Disposal Study of Jamaica Bay.

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RM-5162-PR Programming by Questionnaire: The Job Shop Simulation Program Generator.

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P-4152 Simulation in Field Testing.

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P-3114 A Short Course in Model Design.

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R-642-RC Intrinsic Oscillations in Neural Networks: A Linear Model for the nth-Order Loop.
RM-5598-RC A Simulation Study of Coincidence Detection in the Dendrites of a Single Nerve Cell.
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P-3747 A Model for Continuous Neuroelectric Activity: The Encoding of Stimulus Intensity.

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P-4390 Prevention of Hypokalemic Cardiac Arrhythmias Associated with Cardiopulmonary Bypass and Hemodilution.

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P-3194 Example of a Large-Model Simulation of the Blood Biochemical System.

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P-3518 Prelaunch Checkout in the 1970s.

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RM-4406-NIH Computer Studies of Respiration.
RM-4833-NIH A Two-Compartment Model of the Lung.

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RM-5564-NRL A Method of Objective Contour Construction.
RM-5582-ESSA An Annotated Bibliography of Dynamic Cloud Modeling.
RM-5582/1-ESSA An Annotated Bibliography of Dynamic Cloud Modeling: Supplement.
RM-5870-ESSA Numerical Models of a Tropical Cumulus Cloud with Bilateral and Axial Symmetry.
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P-4315 Atmospheric Modeling, Field Programs, and Decision Systems.

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RM-6132-NASA ECSS: An Extendable Computer System Simulator.

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P-3606 Use of Multiple On-Line, Time-Shared Computer Consoles in Simulation and Gaming.

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P-3528 A General Building Block for Direct Modeling.

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RM-6073-PR Simulation of the Renal Effects of Antidiuretic Hormone (ADH) in Man.
P-3254 On the Control of Urine Formation.

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RM-5426-PR Specifications for a New Jacobian Package for the RAND Chemical Equilibrium Program.

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RM-4662-PR PLANET: Part IV—Depot Repair and Overhaul Simulator.
RM-4663-PR PLANET: Part V—Reports and Analysis Library.
RM-4950-PR PLANET: Planned Logistics Analysis and Evaluation Technique.
P-4228 PLANET: Planned Logistics Analysis and Evaluation Technique—Depot Simulation.

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R-550-PR Using Logistics Models in System Design and Early Support Planning.
P-4140 A General Simulation Model for Information Systems: A Report on a Modelling Concept.

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RM-5955-NIH Theoretical Evaluation of a Patient-Artificial Kidney System Using the Kiil Dialyzer.

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P-4486 A Stochastic Network Approach to Test and Checkout.

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ABSTRACTS

REPORTS

R-460-PR The SIMSCRIPT II Programming Language. P. J. Kiviat, R. Villanueva, H. M. Markowitz. October 1968.

A user's and programmer's manual for SIMSCRIPT II that requires only a basic knowledge of computers and programming language translators (compilers). Sections that are unusually difficult or contain features of limited use are marked with an asterisk. The manual is divided into five chapters, corresponding to five language levels. Level 1 is a teaching language designed to introduce programming concepts to nonprogrammers. Level 2 is a language roughly comparable in power to FORTRAN, but departs from it in specific features. Level 3 is comparable in power to ALGOL or PL/I, but with specific differences, and contains information on the new ALPHA mode for alpha-numeric manipulations, on writing formatted reports, and on internal editing. Level 4 contains the entity-attribute-set features of SIMSCRIPT, which have been updated and augmented to provide a more powerful list-processing capability. Level 5, the simulationoriented part of SIMSCRIPT II, contains statements for time advance, event and activity processing, generation of statistical variates, and accumulation and analysis of simulation-generated data. Two new debugging routines, BEFORE and AFTER, enable the monitoring of six complex processes. 395 pp. (MW)

R-495-PR Rand's Chemical Composition Program: A Manual. M. Shapley, L. Cutler. June 1970.

A user's manual for Rand's digital computer program for solving complex chemical composition problems by determining the distribution of chemical species in multicompartmented systems that minimizes the free energy of the system while conserving the mass of each chemical component. The total program, containing more than 35 subprograms, is flexible. During a run, the user may alter the data—e.g., add extra amounts of some chemicals (stresses), thus changing the model's composition and creating a new problem. He may also control some constants, cause computation and printing of certain measures of amount of error, and request various special computations and messages. Finally, the program may be used by either experienced computer programmers or those unfamiliar with programming methods because, first, the user refers to the data elements by easily remembered alphanumeric names and, second, he gives operation instructions by control cards containing one alphanumeric word. 228 pp. Ref. Bibliog. (LC)

R-505-ARPA Studies in Climate Dynamics for Environmental Security: A Calibrated Analytical Model for the Thermohaline and Wind-Driven Circulation in the Interior of a Subtropical Ocean. R. C. Alexander. September 1970.

A semiempirical model of the circulation immediately beneath the surface frictional layer in middle latitudes of the open ocean. The report contains sections on scaling and calibration, variation of the wind stress parameter to check the calibrated model, and variation of the vertical thermal diffusion parameter. Results are discussed in terms of heat balance components. The temperature distributions calculated are in qualitative agreement with the more detailed numerical model of Bryan and Cox. An increasingly pronounced subtropical high temperature pattern with an increasing wind stress parameter is a feature common to both models. A new result is the lack of appreciable differences in temperature distributions with or without vertical thermal diffusion. This and other results suggest that Welander's purely advective model, suitably calibrated, is a correct first approximation for the intermediate circulation. 33 pp. Ref. (See also RM-5594, RM-6110, RM-6210, Rm-6211.) (MW)

R-514-PR A Markovian Flow Model: The Analysis of Movement in Large-Scale (Military) Personnel Systems. J. W. Merck, K. Hall. February 1971.

First of a series of reports describing a model of social mobility to provide information concerning patterns of movement, projections of the existing population into the future, and the impact produced by changes in the rate of movement. The model and computing procedures permit personnel managers to create an information system that describes the social and geographic mobility that military personnel continually undergo. Derived from mathematical concepts of Markovian processes, the model is presented as a series of FORTRAN subroutines capable of being used on a variety of contemporary computers. The model's principal attribute is its capacity to create future expected values given the starting distributions and a matrix of transition probabilities. Other options, ranging from the computation of the transition matrix to the comparison of projections under different conditions, are peripheral subroutines of the model, but give it the flexibility required for complete analysis of the movement of members of a population. (See also R-534, R-535.) 131 pp. Ref. (KB)

R-560-NASA/PR Experience with the Extendable Computer System Simulator. D. W. Kosy. November 1970.

A review of the capabilities of the prototype Extendable Computer System Simulator conceptually described in RM-6132, pointing out strengths and weaknesses of this approach to computer system simulation, and indicating general design principles for computer system simulation language. ECSS complies with these principles in being powerful, flexible, readily extended, easily used, and in producing models that are economical to rerun. However, the user should be given more leeway for unusual cases, including greater freedom to skip undesired operations via a more extensive set of procedural statements. A computer system simulation language should also include automatic collection of statistics, with output summaries or trace output available on demand. A representative ECSS program is appended. 36 pp. Ref. (MW)

R-585-PR Tidal Oscillations in the Thermosphere and Their Implications for Upper Atmosphere Density Models. E. S. Batten. September 1970.

A study of the variation of atmospheric parameters in the lower thermosphere (80-150 km) in terms of the theory of atmospheric tides. The existing tidal theory is expanded to include the effects of dissipation and excitation in the thermosphere. The effects of heat conductivity and absorption of solar radiation in the thermosphere are added to the existing tidal theory. The results are then compared with observations of winds in the lower thermosphere to determine the extent to which the tidal theory can explain the observed variations of meteorological variables in the lower thermosphere. Results indicate that many features of lower thermospheric wind profiles can be explained in terms of tidal theory, including the effects of dissipation and thermospheric heating. However, additional dissipation and, for some tidal modes, additional excitation is indicated. Further development of the tidal theory will lead to an atmospheric density model in the range of 100-150 km that can be used for improved satellite position predictions. 127 pp. Bibliog. (Author)

R-632-NYC A Simulation Model of Fire Department Operations: Design and Preliminary Results. G. M. Carter, E. Ignall. November 1970.

A simulation model designed to compare different policies for locating, relocating, and dispatching fire-fighting units is described. Issues treated include: the use of internal measures of performance as proxies for global ones; the use of analytical models for various subproblems to yield policies to be tested; the handling of loss of life and other important but rare events. The SIMSCRIPT I.5 simulator and input and post-simulation analysis programs are described. Results that have been used by the Fire Department of the City of New York are presented and analyzed. 44 pp. Ref. (Author)

R-641-PR Generating Gamma Distributed Variates for Computer Simulation Models. M. B. Berman. February 1971.

Compares two methods of generating random variates for simulation studies from gamma distributions with non-integral shape parameters. The commonly used probability switch approximation method is examined for accuracy and computation costs, while Johnk's exact method is investigated for computation costs. The probability switch method approximates the gamma distribution very closely for shape parameters above 5.0, poorly between 1.0 and 5.0, and not at all below 1.0. Johnk's method, while exact, is 2.5 to 3 times slower in the shape parameter range of 1.0 to 5.0. Johnk's method is recommended for shape parameters below 5.0, and the probability switch method is recommended above 5.0. FORTRAN routines for the two methods are provided. The data used to investigate the accuracy of the probability switch method is appended, as are selected plots of the distributions and a discussion of methods to generate beta variates. 52 pp. Ref. (Author)

R-642-RC Intrinsic Oscillations in Neural Networks: A Linear Model for the nth-Order Loop. R. J. MacGregor. February 1971.

A preliminary study of the inherent dynamic properties of feedback pathways composed of millions of brain cells. The ultimate aim is to predict feelings and behavior from the anatomical arrangement of nerve cells. This report maps the characteristic modes of oscillation for cells in a single closed loop—a linearized generalization of the interconnection pattern found in the hippocampus of the mammalian brain. Any or all cells may be externally stimulated, may activate or be activated by any other, and may contribute output individually or jointly, all with time lags. The analysis suggests that to possess many different persisting modes, a loop should have many cells with high average interunit conduction time and a large mean connective coefficient. This may be expected in cell networks with long, thin, unmyelinated axons and strong interconnections, such as the open system networks of the lateral hypothalamus and the brain stem reticular formation. 47 pp. Bibliog. (MW)

RAND MEMORANDA

RM-4219-ISA (Abridged) The Army Deployment Simulator. W. F. Sharpe. March 1965.

Description of a computer program to simulate the deployment of Army units via transport aircraft from peacetime locations to actual or potential combat areas. The program, written in FORTRAN IV for the IBM 7044, can be adapted for use on any of several large-scale computers. A typical deployment problem is used to illustrate the various phases of the system. Appendices list inputs and outputs for the sample problem. 82 pp.

RM-4242-PR Modify and Restart Routines for SIMSCRIPT Experiments. H. M. Markowitz, R. C. Steorts. June 1965.

A presentation of routines to be used with any SIMSCRIPT simulation program. They provide snapshot, modify, and restart capabilities for the following game and experiment applications: (1) man/machine games in which the computer simulates a system for a period of time, humans then use the results to decide on changes in policy parameters for the following period, and the computer resumes simulations where it left off but with policy parameters modified; and (2) simulation experiments in which snapshots of the simulated system are recorded on tape at various points in time. After inspecting the periodic and summary print-outs produced by the simulation, an analyst may specify a return to some snapshot, modify one or more parameters, and resume simulation at that point. While this revised simulation is running, additional snapshots may be taken so that the process can be repeated. 69 pp.

RM-4347-PR Fluid Balance and Electrolyte Distribution in the Human Body. E. C. DeLand, G. B. Bradham. February 1965.

Presentation of a conceptual model and a mathematical method for computing the physiological fluid and electrolyte distribution for selected body compartments of an average, young, 70-kilogram human male. The mathematical procedure simulates the physiological subsystems by incorporating all the known chemical reactions and electrochemical relations that seem necessary to establish the fluid and electrolyte distribution. The construction of the model and the mathematical background are given in heuristic form only, with reference, for rigorous development, to earlier reports (RM-2519-PR, RM-3212-PR, RM-3707-PR, RM-3935-1-PR). The results of validation experiments, consisting of chemical stresses applied to the model, are discussed. 122 pp. Bibliog.

RM-4393-PR Spectral Analysis of Time Series Generated by Simulation Models. G. S. Fishman, P. J. Kiviat. February 1965.

An application of spectral analysis to the study of time series using mathematical models known as covariance stationary stochastic processes, which are useful representations of autocorrelated time series. A discussion of the rationale, backgrounds, and basic ideas of the study is given. Three simulated experiments are presented as examples of how to apply spectral analysis. 80 pp. (See also RM-3789-PR.)

RM-4406-NIH Computer Studies of Respiration. T. W. Murphy. May 1965.

Part of a continuing study on the application of modern data-processing technology to the analysis of the respiratory and circulatory systems. The calibration of the system is described and the abilities of the device are demonstrated in an investigation of the tidal volume-dead space relationship. Advantages of this approach are discussed. 78 pp. Bibliog.

RM-4460-PR Programming by Questionnaire. A. S. Ginsberg, H. M. Markowitz, P. M. Oldfather. April 1965.

A description of the program generation concept, or programming by questionnaire, a technique for reducing the cost and time required to produce computer programs within specified areas of application. The Memorandum describes the technique, compares it to existing techniques, and discusses potential uses. The method is described in terms of the Job Shop Simulation Program Generator (JSSPG), an example developed to test the feasibility and desirability of the concept. 49 pp.

RM-4579-NIH Spike Probabilities in Neurones: Influence of Temporal Structure in the Train of Synaptic Events. J. P. Segundo, D. H. Perkel, G. P. Moore. December 1965.

Report of experimental work involving electrophysiological measurements and computer simulations of interacting nerve cells. Certain input-output relations are studied by way of intraneuronal recordings in isolated visceral ganglia of Aplysia californica. Experiments in computer-simulated neurons reproduced and extended the results of the animal experiments. One aim of the study is to determine: (1) What temporal configurations of successive presynaptic spikes, imbedded in the presynaptic spike train, presage the occurrence of a spike in the postsynaptic cell? (2) How many presynaptic spikes are significantly involved in influential configurations? (3) What is the effective duration of influential configurations? and (4) What is the effect of postsynaptic refractoriness? 84 pp.

RM-4589-PR Simulation and Evaluation of Logistics Systems. B. J. Voosen. September 1965.

A description of PLANET (Planned Logistics Analysis and Evaluation Technique), designed to increase the possibility of discovering flaws in a weapon system before it becomes operational. Through testing, PLANET can obtain a measure of the costs of logistics support for various hardware configurations and operational requirements. It can also help in estimating needs, at various levels of reliability and maintainability, for maintenance manpower, equipment, and spare parts. Even though PLANET cannot optimize the hardware configuration, it permits examination of different configurations. It thereby allows the planner to quantify the relative effects of decisions during the planning and operating phases of a weapon system. 32 pp.

RM-4659-PR PLANET: Part I—Availability and Base Cadre Simulator. B. J. Voosen, D. Goldman. April 1967.

The computer routines, operating manual, and programmer's manual for the Availability and Base Cadre (ABC) Simulator, one of the four

simulation programs that make up the Planned Logistics Analysis and Evaluation Technique (PLANET). The ABC Simulator is intended to simulate the organizational maintenance activities in a single or multibase environment. The model can be used to simulate missiles or aircraft (in some cases, both). Its structure is very flexible and allows study of a broad range of problems, such as the impact of increased workloads, changes in hardware design and/or operational requirements, manning, and maintenance systems. Nearly every facet of maintenance and other logistics activities is incorporated in the model, including variable personnel staffing by type, base, and shift; travel times with delays and equipment failures; part failure modes and failure levels; maintenance repair time distributions, etc. Although PLANET is programmed in SIMSCRIPT, the user need not be an experienced SIMSCRIPT programmer to conduct a simulation. The step-by-step instructions given in the programmer's manual will enable the user to assemble his data in a form acceptable to the model. The ABC simulator has the capability to rerun a simulation from any point, without repeating the previous execution. 216 pp. Refs. (See also RM-4950-PR.)

RM-4660-PR PLANET: Part II—Bench Repair Simulator. B. J. Voosen, M. H. Buchanan. April 1967.

The computer routines, operating manual, and programmers' manual for the Bench Repair (BR) Simulator, the second of four simulation programs constituting the Planned Logistics Analysis and Evaluation Technique (PLANET). BR is designed to simulate the operations of the various repair shops on an Air Force base. Either one or many shops can be examined with a single simulation. The simulator takes as inputs the shops' operating characteristics and simulates shop operation through time. Performance is measured in terms of repair cycle time and the shops' capacity. Outputs can be used as an aid in determining the resource requirements necessary to support repair actions. The Bench Repair Simulator can be assembled to the Availability and Base Cadre (ABC) Simulator (PLANET: Part I) to examine problems encompassing all base functions: As BR simulates field level support, ABC simulates the organizational level. Together, the two models incorporate nearly every facet of maintenance and logistics at Air Force bases. 200 pp. Refs. (See also RM-4659-PR, RM-4950-PR.)

RM-4661-PR PLANET: Part III—Depot Transportation Simulator. B. J. Voosen, S. Glaseman. April 1967.

Computer routines, operating manual, and programmer's manual for the Depot Transportation (DT) Simulator, the third of four simulation programs constituting the Planned Logistics Analysis and Evaluation Technique (PLANET). The DT simulator is designed to simulate the movement of logistics resources from base to base and from base to depot or factory and return. It takes as inputs the various operating characteristics of the transportation system, the expected cargo to be moved through time, and a planned set of transport vehicles. Outputs from the simulation can be used as an aid in determining the quantity of resources that can be moved over time and the costs associated with the operation of the system. 155 pp. Refs.

RM-4662-PR PLANET: Part IV—Depot Repair and Overhaul Simulator. B. J. Voosen, M. H. Buchanan, S. Glaseman. July 1968.

The operator's manual, programmer's manual, and computer routines for the Depot Repair and Overhaul Simulator (DRO), the final of four simulation programs that are components of the Planned Logistics Analysis and Evaluation Technique (PLANET). DRO is designed to examine the functions normally performed by a depot in converting a reparable to a serviceable. The simulator takes as inputs the depot's operating characteristics, such as the workshift policies, the expected workload through time, and a planned set of resources to operate the depot. It then simulates the depot's operation through time and periodically prints out reports that reflect the performance of the planned set of resources under the conditions specified. Performance is measured in terms of reparable throughput time in relation to the depot's capacity. The outputs can be used as an aid in determining the resource requirements to support the depot's operation. The four simulation programs that make up PLANET can be used separately to examine specific areas of the logistic system, or together to simulate the complete weapon system operation from the site or point of demand through the depot level. 226 pp. Refs. (See also RM-4659-PR, RM-4660-PR, RM-4661-PR, RM-4950-PR.)

RM-4663-PR PLANET: Part V—Reports and Analysis Library B. J. Voosen, R. J. Young, S. Glaseman, J. Judd. January 1969.

A user's and programmer's manual for the 12 programs comprising the Reports and Analysis Library of PLANET (Planned Logistics Analysis and Evaluation Technique), a logistics prediction and estimating tool designed to help the manager of a system to understand its operation and to find a rationale for allocating resources efficiently. PLANET consists of four computer models that simulate Air Force logistics systems in a single or multibase environment. Whether the models are used singly or in various configurations, the output will be a tape listing of selected variables accumulated during the simulation. From this tape the desired reports are generated by using the library of programs. The manager can select those programs best suited for analysis of his particular problem. Although PLANET is programmed in SIMSCRIPT, the user need not be a skilled programmer to conduct a simulation. Stepby-step instructions are included to permit the manager to assemble the data in a form acceptable to the simulations. Part 1 of the Memorandum contains a brief description of each of the reports and the SIMSCRIPT instructions needed to initialize any of the report programs. Part 2 is the library of programs, including the initialization requirements, a program description oriented to the skilled SIMSCRIPT programmer, and a listing of the SIMSCRIPT SOURCE program. 303 pp. Refs. (See also RM-4659, RM-4660, RM-4661, RM-4662.) (MW)

RM-4716-NIH Segmental Differential Approximation and Biological Systems: An Analysis of a Metabolic Process. R. E. Bellman, R. S. Roth. February 1966.

Mathematical formulation of a complex system suggested by a metabolic process. The formulation allows for certain subprocesses to operate over finite time spans within the time intervals. Central to the mathematical formulation are the observed experimental data. It is assumed that some information is available for each operating subprocess. A computational method of solution is suggested. 26 pp. Bibliog.

RM-4782-PR A Computer Simulation of Adaptive Routing Techniques for Distributed Communications Systems. B. W. Boehm, R. Mobley. February 1966.

Description of a computer model of a distributed communications system. It is written in FORTRAN IV and is designed to test various adaptive message routing techniques. The program simulates the progress of messages through the system and measures the effects of the routing techniques' adaptation to specified degrees of destruction of its links and nodes. A listing of the program is given, plus the pitfalls to avoid in developing similar programs. 44 pp.

RM-4816-PR Neuronal Spike Trains and Stochastic Point Processes. D. H. Perkel, G. L. Gerstein, G. P. Moore. March 1967.

The mathematical theory of stochastic point processes in its probabilistic and statistical aspects is applied to nerveimpulse sequences. Mathematical results are extended and illustrated through the application of statistical techniques to the results of computer experiments on simulated nerve cells. Statistical techniques at several levels of complexity are used in the analysis of single stationary spike trains. A set of techniques is presented for analyzing two spike trains simultaneously in the presence and absence of stimulation. It is shown how to test for independence of the two cells and to diagnose the sources of dependence when found. The effects of trends in the data on the computational results are discussed and illustrated. 147 pp. Refs.

RM-4833-NIH A Two-Compartment Model of the Lung. T. W. Murphy. January 1966.

A report on the modeling of gas exchange in the lung. The author derives the differential equations for changes in gas concentration with time in the two-compartment model of the lung, and graphs the solutions by digital simulation. Estimates of the fluctuations in alveolar gas partial pressures and in exhaled gas partial pressures are given, and it is shown that the model simulates cardiogenic oscillations in the exhaled gas curve. It is also shown that the consequences of cyclic ventilation and perfusion of the lung, coupled with non-linearities in the content-pressure relationships for blood and gas, cause some differences between the mean partial pressure of a gas in the lung gas and in the lung blood.

This effect is demonstrated in both an intuitive and mathematical manner, and a computational approach is described. The magnitude of the effect is computed for carbon dioxide and oxygen. 43 pp. Bibliog.

RM-4880-PR Problems in the Statistical Analysis of Simulation Experiments: The Comparison of Means and the Length of Sample Records. G. S. Fishman. February 1966.

A continuation of research into statistical analysis of simulation experiments containing autocorrelated time series. The Memorandum shows how to estimate the lengths of sample records needed to use certain large sample results in measuring stability, describes analogies between autocorrelated data and independent observations, and suggests a way to test the difference of the mean of two experiments. It also shows how the variance of the sample mean relates to the spectrum of the generating process, and describes estimation of the quantities of interest. The results expand the possibilities of statistical spectral analysis as applied to simulation experiments. 29 pp. (See also RM-4393-PR.)

RM-4923-PR A User's Manual for SAMSOM II: The Support Availability Multi-System Operations Model. T. C. Smith, G. D. Brown, P. A. Mason, R. Moulenbelt, H. J. Shukiar. November 1967.

A description of the capabilities of SAMSOM II, RAND's operations model for the simulation of aircraft operations and logistics support problems. The manual provides information on input requirements, model logic, and operating instructions; it also describes model outputs and includes a sample simulation to familiarize the user with model operational details. Although designed primarily to simulate typical Air Force operations, SAMSOM II may be used to examine the operational capabilities of other organizations or combinations of aircraft and logistics support elements. The model also simulates operations for one or more weapon systems at one or more bases involving multiple resource allocations and operational requirements. SAMSOM II should prove useful to analysts and managers responsible for monitoring weapon system developments, estimating operations capabilities, and determining logistics support requirements. 287 pp. Bibliog.

RM-4939-PR Statistical Techniques for Detecting and Classifying Neuronal Interactions. D. H. Perkel. June 1966.

An examination of mathematical techniques for comparing two simultaneously recorded neuronal spike trains and a presentation of a computer simulation using these techniques. 39 pp. Bibliog.

RM-4945-PR An Interdiction Model of Highway Transportation. E. P. Durbin. May 1966.

Description of a computer program to evaluate the capability of transportation networks to deliver supplies, as road segments or arcs of the network are successively destroyed and repaired. The program, written in FORTRAN IV, can be adapted for any of several large-scale computers. Required inputs are a description of the considered transportation road system and the cargo-carrying vehicles using it. The program furnishes a profile of maximum cargo flow as a function of the number of vehicles available to the system, then destroys the link in the network that reduces cargo flow rate most severely. These steps are repeated until network flow is stopped or predesignated links destroyed. The program then steps to the next period, restores service to all previously destroyed links now repaired, and repeats the process of profile generation and link removal. The program will accept a network up to 1000 links. 34 pp.

RM-4950-PR PLANET: Planned Logistics Analysis and Evaluation Technique. P. J. V[illegible]. January 1967.

A description of the PLANET model, which is a series of four computer simulation programs designed to examine the hardwareconfiguration/operations/logistics-support interactions of a variety of weapon systems in a single-base or multi-base environment. The author concisely describes the four simulators and the twelve output programs contained in the Reports and Analysis Library of the model and discusses the capabilities and limitations of the PLANET complex. 43 pp.

RM-4962-PR The Classical Structure of Blood Biochemistry - A Mathematical Model. E. C. DeLand. July 1966.

A mathematical simulation of human blood biochemistry that includes the results of a detailed chemical analysis of human blood under a variety of chemical stresses. Mathematical simulations of increasing degrees of complexity are developed. A rudimentary blood model assumes the conventional roles of the fixed proteins, the neutral electrostatic charge constraints, and the active cation pump as the major characteristics of hemostatic blood. The microscopic properties of the proteins, particularly their buffering behavior, are incorporated into the model by a mathematical procedure that assumes that the serum albumin and the various globulins represent all of the important buffering power of the plasma fraction. A model of the respiratory biochemistry of the blood, embodying the results of the previous biochemical structural detail, is tested under various conditions. Properties of the mathematical model, such as gas exchange, buffering, and response to chemical stress in the steady state, are practically indistinguishable from those properties of real blood within the limits of the present validation program. 135 pp. Refs.

RM-5005-NASA Report on a Demonstration Test of Computer-Assisted Countdown. S. M. Drezner, O. T. Gatto, T. D. Wisniewski. March 1966.

An investigation of the interaction between man and computer in a countdown environment. Possible benefits and problems of extending computer control are also explored. The demonstration test examines countdown from the executivecontrol level, i.e., launch director, test supervisor, or launch-vehicle test conductor. Tests and operations appear as in a normal countdown script. Major hardware test components consist of the computer and the Rand Tablet, a man/machine graphical communication device. Using the Rand graphic system, the executive can experiment, interrogate, predict, issue commands, and receive responses on a cathode ray tube display from the central processing unit. Outputs presented include information dealing with time, script, status, and operational and engineering data. The test introduces an innovation that enables the executive to act on-line with a simulation of the countdown: he can make changes to the script or to the simulation. 38 pp.

RM-5110-NASA A Numerical General Circulation Experiment for the Atmosphere of Mars. C. B. Leovy, Y. Mintz. December 1966.

A numerical experiment for simulating the general circulation of the atmosphere of Mars is described and preliminary results from an initial experiment are given. The experimental conditions correspond to the Northern Hemisphere winter solstice on a planet, in the orbit of Mars, having an atmosphere composed entirely of CO and an initial surface pressure of 5 milibars. Important features indicated by the model are development of a fluctuating wave regime in the winter hemisphere, a large amplitude diurnal tide, and condensation of CO to form a winter polar ice cap. The preliminary character of this experiment is stressed and some future improvements are proposed. 51 pp. Refs.

RM-5129-PR Programming by Questionnaire: How to Construct a Program Generator. P. M. Oldfather, A. S. Ginsberg, H. M. Markowitz. November 1966.

A reference manual for the Programming by Questionnaire technique, presented in sufficient detail to enable a programmer to construct a program generator. Familiarity with the content of RM-4460-PR would be helpful to the user, and a knowledge of SIMSCRIPT is mandatory. The forms, use, and operation of the four components of the program generator are described in detail. A summary of technical details and a complete Editor program listing are included as appendixes. 153 pp.

RM-5145-PR A Simplified Model of Aircraft Sortie Generation Capability. E. V. Denardo. February 1967.

An analysis of the steady-state performance of an aircraft subjected to a maximum daytime flying effort under the condition of unlimited maintenance resources. The uses of the model are discussed, and the results of some 200 computer runs are described. One group of runs measures the sensitivity of the performance of the aircraft to the description of the maintenance function. Another group measures the sortie generation capability as a function of the length of the flying day, the length of the flight, and the mean turnaround time. 49 pp.

RM-5153-ARPA Hardware Aids for Automata Design. N. B. Reilly. December 1966.

A description of the hybrid computing hardware of a system designed to provide basic building blocks from which large neural networks can be constructed. The relationship of these building blocks to automata theory is discussed, and their possible usefulness in the construction of neural nets is examined. A simple network, containing at least one representative of each of five basic types of circuits, is constructed and the logical properties of the building blocks are described. An appendix gives detailed descriptions of the required circuitry and control functions. 39 pp. Refs.

RM-5162-PR Programming by Questionnaire: The Job Shop Simulation Program Generator. P. M. Oldfather, A. S. Ginsberg, P. L. Love, H. M. Markowitz. July 1967.

A description of the Job Shop Simulation Program Generator, an application of the Programming by Questionnaire technique developed at RAND to reduce the cost and time required to produce large computer programs, particularly those required for simulations of portions of the Air Force logistics system. The user can obtain a computer program by filling out a multiple-choice questionnaire covering aspects of the job shop he wishes to simulate. Answers are punched on seven cards that are fed to the program generator, which checks the answers for consistency, generates the program, and produces the data specifications. The user then completes the data deck according to the specifications, adds it to the end of the program deck, and submits the entire program to the computer. The output consists of interim reports on resource utilization, job statistics, and queue statistics, and a final summary report. The functions of the various routines and the meaning of the variables in the SIMSCRIPT definition deck are given for the use of SIMSCRIPT programmers. 115 pp. Refs.

RM-5183-PR The Application of On-Line Graphical Techniques for Programming and Operating a Moving Network Monitoring Display. L. Chesler, R. Turn January 1967.

Describes the structure and operating procedures of experimental computer programs used to simulate a real-time moving network display of spacecraft checkout operations. Proposed in RM-4678-NASA for use by the human monitor of an automated prelaunch checkout, the system dynamically shows, in network form, the successive and concurrent stages of a complex process. The programs were written in MAP for the IBM 7040/7044 computer system to be used with the RAND Graphic Input Tablet and a cathode ray tube display screen. The Tablet is used for on-line construction of the initial network and for operation of the simulation programs. (A complete program listing is available on request.) 98 pp. (See also RM-4122-ARPA.)

RM-5235-PR A Programmer's Guide to SAMSOM II. G. D. Brown, R. Moulenbelt, H. J. Shukiar. November 1967.

A technical manual for programmers concerned with modifying or adapting programs of SAMSOM II, RAND's Support Availability Multi-System Operations Model, to a particular computer installation. The guide is divided into four major sections, one for each of the three programs that comprise SAMSOM II—INPUT, EXECUTION, and OUTPUT—and a fourth section dealing with problems common to the three programs. The analysis covers output program logic, subprograms and general flow, program conversion, and debugging procedures. 212 pp.

RM-5244-PR Mathematical Analysis and Digital Simulation of the Respiratory Control System. F. S. Grodins, J. Buell, A. J. Bart. March 1967.

A numerical simulation of the lung-bloodbrain-tissue gas transport and exchange system. The basic material balance relationships are expressed in a set of differential-difference equations containing a number of dependent time delays based on blood flow rate and vascular capacity. Other equations define the chemical details of transport and acidbase buffering, concentration equilibria, and blood flow behavior. A control function is given defining the dependence of ventilation on hydrogen ion concentration in the cerebrospinal fluid and oxygen content at the carotid chemoceptors. A 500statement FORTRAN program simulates the responses of the system to a variety of forcings, including carbon dioxide inhalation, hypoxia at sea level, altitude hypoxia, and metabolic disturbances in acid-base balance. Both dynamic and steady-state behavior were reasonably realistic. About one minute machine time on a CDC 3400 computer was required for every four minutes of simulation. To the authors' knowledge, this is the first digital solution of a set of differentialdifference equations whose time delays are themselves dependent variables. 56 pp. Refs. (See also RM-4962-PR, RM-4990-NIH.)

RM-5262-PR A Mathematical Model of Placental Oxygen Transfer. T. H. Kirschbaum, N. Z. Shapiro. August 1969.

A mathematical model of placental oxygen transfer is used to argue that the experimentally observed control of fetal oxygen concentration in fetal lambs can be explained by the nature of oxyhemoglobin dissociation functions and the differences between these functions in fetal and maternal blood. It is not essential to the explanation to posit any mechanisms responding to a p02 sensor or any changes in fetal, maternal, or placental vascular structures. Equally unnecessary are assumed alterations in the physical or chemical structure of placental membranes. 53 pp. Refs. (Authors)

RM-5272-PR A Mathematical Model for Post-Irradiation Hematopoietic Recovery. J. P. OKunewick, A. L. Kretchmar. July 1967.

A mathematical model of the recovery after irradiation of the system producing blood cells in the body. The model is based on the hypothesis that hematopoietic stem cells, which are unable to reproduce as stem cells following irradiation, may still retain an ability to differentiate. The model demonstrates both an abortive recovery rise and a true recovery rise following irradiation. As a first approximation, the model shows no irreconcilable differences from experimental data and generally represents the phenomena observed in the recovery of erythropoiesis following acute irradiation. In addition, certain postulates basic to blood-cell development are derived. 42 pp. Refs.

RM-5288-1-PR Digital Computer Simulation: The Allocation of Computer Time in Comparing Simulation Experiments. G. S. Fishman. October 1967.

An improved step-by-step procedure for minimizing the computer time needed to obtain a specified statistical precision in the comparison of simulation experiments. The simulations are considered as covariance stationary stochastic processes, as explained in RM-4393-PR. Well-known timesaving methods for reducing variance by inducing positive correlations between the experiments and high negative correlations between replications are included in the procedure. Results show that for a given level of accuracy, significantly less computer time is required when sample sizes are determined by the method suggested in this study than when they are equal. Also, small differences in the autocorrelation functions are important when each process is highly correlated. The suggested two-stage procedure provides initial estimates for determining sample sizes and final estimates for testing hypotheses. Graphical analysis suggests that the efficient allocation is not very sensitive to small errors in the estimates of population parameters. 32 pp. Refs.

RM-5294-PR Aspects of a Computational Model for Long-Period Water-Wave Propagation. J. J. Leendertse. May 1967.

Derivation of a computer model for simulating the propagation of long-period waves in relatively shallow water with complex boundaries, such as in bays and estuaries, and along coastlines, and extensive experimental comparisons of simulated with real wave histories in Tokyo Bay, a Rhine estuary, and the southern North Sea. The numerical techniques apply to the propagation of water waves, such as tides, surges, seiches, tsunamis, and explosion-generated waves some distance from the explosion in shallow water. Computation is based on a new method of numerical integration of the hydrodynamic equations, taking into account vertical motion and the effects of earth rotation and ocean floor topography. Two different sets of approximations to the partial-differential equations are used successively for the step-by-step solution over time. A fast, realistic, and unconditionally stable computation can be made by the multioperation method. A computer-driven S-C 4020 microfilm recorder was used to plot the currents and water levels. A guide to the

FORTRAN IV wave program enables the program to be used by hydraulic engineers without knowledge of programming. Information for making changes in the procedure is also given. 179 pp. Refs.

RM-5370-PR Priority Dispatching and Assembly Operations in a Job Shop. W. L. Maxwell. October 1969.

An experimental investigation of priority dispatching in a job shop whose output feeds into an assembly shop. Procedures are investigated for meshing the jobs of a product by either (1) having jobs progress at the same rate based on information about the number of operations remaining, or (2) having jobs completed by some due date. Two-level priority procedures are presented that group jobs by how critically their completion affects the assembly of their product, and then use a shortestprocessing-time (SPT) method within these major groupings. Statistics are collected that indicate where congestion occurs and help in deriving some of the priority rules. It is found that better overall performance is achieved by combining the SPT rule with product-oriented rules. Areas for future research include both procedures (e.g., the use of SPT in the job shop) and the assembly environment. 35 pp. Refs. (CC)

RM-5376-PR A Mathematical Model of the Chemical Distribution in a Disease State: Hypothyroidism. M. B. Wolf, E. C. DeLand, J. V. Maloney. June 1969.

Models of fluid and electrolyte distribution in a standard (euthyroid) dog and a hypothyroid dog. The model of the euthyroid dog was altered by adding a new fluid compartment, Colloid, to conform to a hypothesis of body chemistry changes in hypothyroid animals as determined from the literature. Both euthyroid and hypothyroid laboratory dogs received injections of acid solution to provide chemical data for comparing chemical distribution and for validating the models simulating these states. The results proved statistically that hypothyroid dogs respond differently from normal ones to acid infusion. However, the hypothyroid model did not predict these experimental results well. Although laboratory technological problems accounted for many of these discrepancies, additional experiments and other chemical perturbations are necessary to test the biochemical hypotheses formulated in this study. 72 pp. Refs. (MJP)

RM-5378-PR Digital Computer Simulation: Modeling Concepts. P. J. Kiviat. August 1967.

A discussion of the basic concepts of the techniques of digital computer simulation: the study provides a rationale for simulation, discusses the design and construction of simulation models, and relates simulation as a technique to current problems in simulation technology. Simulation is defined as the use of a numerical model to study the behavior of a system as it operates over time. Emphasis is on models that are implemented on digital computers —that is, models that operate by advancing a system through time in discrete steps rather than continuously, as is done with analog computers. Because it is an experimental numerical technique, simulation is usually more expensive than analytic solutions; nevertheless, it is widely used for complex problems that cannot be solved analytically, such as those encountered in engineering and management studies. Even certain structurally simple analytical models must be simulated because their statistical properties do not admit analytic solution. Simple models are broad in scope and contain few assumptions; complex, highly structured models are narrow in scope and contain many assumptions. Before a simulation model is designed, it is important to determine what use will be made of it and what are the requirements of accuracy and precision. A model should only be as detailed as is necessary to answer the questions at hand. 63 pp. Refs.

RM-5379-1-NASA Transionospheric Propagation of FM Signals. E. Bedrosian. August 1967.

An analysis of the intermodulation, or distortion, experienced by a wide-band frequency-modulated signal as it is transmitted through the earth's ionosphere between a satellite and a terrestrial station. The ionosphere is modeled as a generalized linear filter, and a spectral analysis of the demodulated signal is performed assuming a gaussian modulating waveform. Formulas are obtained for the output signal-to-distortion and signal-tocross-talk ratios. Two cases of current interest are examined numerically. The first typifies a high-capacity communication link of the Intelsat variety, and it is seen that significant degradation can occur only under the most unusual circumstances. The second considers a wide-band TV transmission near the upper end of the UHF TV band; in this case, ratios of about 20 db result. It is difficult to judge how objectionable such distortion would be to viewers because it differs spectrally from the snow produced on conventional TV by thermal noise and displays a strong correlation with the signal. Color transmission could suffer synchronizing errors. 50 pp. Refs.

RM-5387-PR Digital Computer Simulation: Statistical Considerations. G. S. Fishman, P. J. Kiviat. November 1967.

A discussion of the statistical problems that arise in computer simulation experiments. Three problem areas inherent in all stochastic system simulation models are discussed: verification, which determines whether a model actually behaves as an experimenter assumes it does; validation, which tests whether the model reasonably approximates a real system; and problem analysis, which seeks to ensure proper execution of a simulation and proper handling of its results. The study traces the elements of a simulation experiment from initial conception to analysis of final results, defining the statistical problems that arise at each step and relating them to the formal body of statistical theory. Since the aim is to promote awareness of problems, not to solve them, the study offers no general solutions but provides references germane to the statistical problems described. 41 pp. Refs. (See also RM-5288-1-PR, RM-5378-PR.)

RM-5392-PR Speculations on Physicochemical Fluid Properties in Physiological Regulation. J. C. DeHaven, N. Z. Shapiro. October 1968.

An examination of the proposition that certain physicochemical properties of biological fluids contribute to maintaining the steady-state concentration gradients that occur in physiological systems. Simple electrostatic solution theory is used to demonstrate that differences in ionic strength and dielectric constants of fluids separated by simple membranes can produce large concentration gradients for uncharged organic substances between the fluids. The magnitude of the gradients, and whether they are greater or less than one, depends on the electrostatic characteristics of the fluids and on the size and signs of the dielectric increment of the substances. Hormones are among the most potent chemicals that affect the distribution of substances between body compartments. With antidiuretic hormone as an example, computations are made that show that this hormone can alter the dielectric constant of plasma so as to change the activity of water from that of diuretic urine to that of concentrated urine in the hydropenic static. This protein-interactive, bulk fluid mode of hormonal influence is suggested as a basis for explaining certain presently unexplained hormonal actions and interactions. 63 pp. Refs. (LK)

RM-5396-PR Unique Mathematical Models of Individual Blood. E. C. DeLand, E. Magnier, J. V. Maloney. May 1970.

Investigates mathematical, computer-based methods of simulating the blood composition of individual clinical patients. Earlier studies developed procedures for constructing models of the respiratory function and acid-base biochemistry of statistically normal human blood. This memorandum extends these procedures and shows that, with sufficient laboratory data, such a model can be derived for individual patients, and conjectures that the blood's chemical pattern may indicate the patient's physical condition. Such models may be useful for clinical and experimental fluid therapy. The models described simulate the steadystate distribution of chemical species (particularly proteins, electrolytes, and water) between the plasma and red blood cells at one instant, but not the kinetics or time-dependent states of such systems. In 30 separate laboratory experiments, a model of individual blood was tested against real blood 2in vitro, under various chemical stresses. Results indicate satisfactory agreement. 108 pp. Ref. Bibliog. (LC)

RM-5404-PR CHEMIST—The RAND Chemical Equilibrium Program. E. C. DeLand. December 1967.

A detailed report on the structure and use of CHEMIST, a RAND computer program designed to simulate complex chemical equilibria. The study was compiled in response to a growing demand for a reference manual to accompany and document the program. CHEMIST is a program for use by professionals not trained in computer programming.

Communication with the program is in English, chemical, and FORTRAN languages. The computer code currently exists in FORTRAN IV for the IBM 7044. In its present form it occupies approximately 25,000 words for the principal part. Additional specialized subroutines not essential to the operation can increase space requirements. The program uses an iterative mathematical programming technique to determine the composition that minimizes the total free energy of a chemical system, subject to system constraints. A detailed program description with examples is given, along with the program subroutines. The References and Selected Bibliography comprise as complete a listing of the literature as is currently possible. This manual will be updated as the CHEMIST program evolves further. 143 pp. Refs. Bibliog.

RM-5426-PR Specifications for a New Jacobian Package for the RAND Chemical Equilibrium Program. M. Shapley, L. Cutler, J. C. DeHaven, N. Z. Shapiro. January 1968.

This study describes and gives instructions for using a new and improved Jacobian package consisting of a group of subroutines for RAND's chemical equilibrium program. This new package, which has a much greater scope than the earlier version, computes Jacobian matrices consisting of partial derivatives of certain quantities in the solution of a model (dependent variables) with respect to certain parameters in the model (independent variables). With the use of these derivatives, it is possible to predict how a change in a model parameter can affect the model solution. In many cases the user can obtain a good approximation for how much effect a certain type of change will have without resolving the problem. The derivatives might be used, for example, to see how much the pH of a model might change with an increase in the pressure of carbon dioxide, or with an increase in the amount of sodium hydroxide. 55 pp.

RM-5451-PR Acid-Base Metabolism and the Proton Condition. C. D. Russell. December 1967.

Application of the proton condition of inorganic chemistry to the problem of describing the net acid content in a biological system. A proton content is defined that expresses the net acid content in terms of the detailed chemical composition of the system. This approach is compared with previous approaches to the quantitative description of acid-base metabolism and is then applied to the interpretation of experimental metabolic balances. The principal advantage of the mathematical formalism described in this study is that its use pinpoints the assumptions and makes it possible to handle unusual cases simply by including terms that are normally neglected. 53 pp. Refs.

RM-5517-ISA A Model for Simulating Underway Replenishment Ship Operations. T. W. Sikes. January 1968.

A listing and description of the FORTRAN IV simulation program for resupply at sea. This model was the principal analytical tool used in preparing RM-5155-ISA. Each simulation run accommodates as many as 32 cases wherein the activities of up to 20 carrier task groups (CTGs) are examined for 90 days. The CTGs are resupplied with oil or ammunition by underway replenishment (unrep) ships cycling between base and up to eight unrep locations. The task groups operate according to an input schedule that is always met, and the program determines the number of logistics ships needed to meet requirements. Daily printouts record the location, activity, receipts or issues, and inventory of each task group and each unrep ship, and at the end of the 90-day simulation runs a final summary printout is made. Unlike most computer simulations, this model has no built-in stochastic features; input data decks can be randomized, if desired. The main routine and nine subroutines have extensive internal documentation and commentary. 79 pp.

RM-5519-1-PR Theaterwide Tactical Fighter Combat Operations Model (TAFCOM): A Program Description. K. G. Brown, C. Huber. November 1969.

An updated programmer's manual for the TAFCOM simulation described in RM-4868. TAFCOM simulates large-scale air attack; it can handle thousands of air-craft with hundreds of bombers attacking tens of targets and penetrating through up to 20 air defense systems of varying effectiveness. TAFCOM assigns sorties to targets, selects and records the ordnance, computes in detail the attrition by SAMs, AA, and interceptors and the target damage inflicted. Each simulated day is run as two separate attacks, with roles reversed for the second run. Written in FORTRAN IV, TAFCOM consists of 84 programs and subprograms arranged in 10 chained links in order of execution; data required by all links are calculated once and kept in core. TAFCOM has been converted for IBM 7094 and 360 computers and the CDC 3600, and is currently in use at the SHAPE Technical Centre. 109 pp. (MW)

RM-5540-PR Digital Computer Simulation: Input-Output Analysis. G. S. Fishman. February 1968.

Procedures for determining the result of a change in inputs to a system simulation. The study discusses the reliability of an experimental result and describes methods of estimating it. The method recommended uses a single replication and makes use of the covariance stationarity of the underlying stochastic process. The comparative reliability of results for different experiments is also discussed. For comparing experiments, it is suggested that reliability based on equal ratios is often preferable. A procedure for graphical analysis is presented, including a list of transformations of the dependent variable that help to reveal the correct form of the relationship between input and output. The generalized least-squares method for estimating the parameters of the identified form takes into consideration the varying reliabilities of the different results and leads to more efficient estimates than those obtained by the unweighted least-squares method. A procedure is given for predicting the computer time needed for a given input and a specified reliability. 32 pp. Refs. (See also RM-4393-PR, RM4880-PR, RM-5288-1-PR.)

RM-5544-PR The Logistics Composite Model: An Overall View. R. R. Fisher, W. W. Drake, J. J. Delfausse, A. J. Clark, A. L. Buchanan. May 1968.

A description of the Logistics Composite Model (L-COM), a computer model developed to simulate the overall operations and support functions at an Air Force base. L-COM consists of three main programs: a preprocessor, a simulation program, and a postprocessor. The model replicates the flying of aircraft; accomplishment of servicing tasks; incurrence of malfunctions; flight-line maintenance; repair of components in base repair shops; the utilization and interaction of resources in the demand process; and the changes in resource availability according to shift policies. L-COM has two unique features: (1) a task network that describes base processes to be simulated by identifying particular tasks and the sequence for accomplishing them; and (2) embedded decision routines that help determine a best mix of resources to support a prescribed flying program. The model requires a computer with an internal memory of at least 65,000 words of 36-bit length or equivalent. A typical problem requires from 1 1/2 to 2 minutes of computer time to simulate a day's worth of base operations involving 1500 tasks. Since L-COM is written in SIMSCRIPT, almost any computer of sufficient size may be used. 114 pp.

RM-5553-NSF Numerical Modeling of Condensation. L. R. Koenig. August 1968.

Molecular diffusion causing mass transfer to and from cloud droplets is modeled by two systems of equations. Predictions of growth behavior made by the two systems are compared with one another and with other formulations in the literature, using Euler, Adams-Moulton, and Runge-Kutta integration procedures. The effects of various refinements, such as corrections to diffusion and conductivity coefficients, are examined. It is concluded that the simpler model integrated by the Euler method, and without refinements, is adequate for most meteorological purposes. 53 pp. Refs.

RM-5564-NRL A Method of Objective Contour Construction. F. W. Murray. February 1968.

A method for automatically constructing graphical contours of large numbers of data fields, such as those produced by many numerical models used in meteorology and other branches of geophysics. The data are most conveniently analyzed by drawing contours of the dependent variables on a grid representing two independent variables. Quite acceptable contours can be generated by RAND's simple generalpurpose method, which uses the General Dynamics S-C 4060 computer-driven electronic graphical plotter. The computer (1) scans all the grid squares once for each value corresponding to a contour to be drawn, (2) finds, by linear interpolation, all the points where the contour intersects the edge of a

grid square, and (3) instructs the graphical-output device to connect these points by straight lines. The program computes raster numbers for the two coordinates of each endpoint of each segment; there are a total of 41 possible conditions, each requiring its own method of computation. The output is not drawn directly on paper but appears on the cathode ray tube display screen, where it can be photographed. A flowchart of the program logic and samples of the output are included. 32 pp.

RM-5582-ESSA An Annotated Bibliography of Dynamic Cloud Modeling. F. W. Murray. March 1968.

A selective bibliography, with informative abstracts of papers related to the numerical simulation of cloud dynamics, including significant works from the Russian and Chinese. Some representative works have been included that model clouds as idealized bubbles or plumes. However, the emphasis is on models involving the solution of hydrodynamic and thermodynamic equations by numerical methods using a digital computer. Cloud microphysics, laboratory studies of convection, and field observations are in general excluded. Several works are listed primarily for their historical interest, including those that introduce the basic thermodynamic equations of water in clouds, the term pseudo-adiabatic, the parcel and slice methods of analysis, and the concept of entrainment. 40 pp.

RM-5582/1-ESSA An Annotated Bibliography of Dynamic Cloud Modeling: Supplement. F. W. Murray. November 1968.

A bibliography of material dealing with numerical cloud models, experiments, and methodology. It covers the period from March to November 1968 and contains twenty-four entries. Some Russian-language publications are included. This Memorandum is a supplement to RM-5582-ESSA. 12 pp. (KB)

RM-5598-RC A Simulation Study of Coincidence Detection in the Dendrites of a Single Nerve Cell. R. J. MacGregor. December 1969.

Results of simulations indicating the ability of a typical nerve cell to discriminate between coincident pulses as compared with two pulses a short timeinterval apart. The simulations are performed with a model for neuroelectric coding processes in a single cell, which includes a representation of dendritic geometry. For this model: (a) the probability that an output spike will be associated in time with a coupled pair of input pulses originating at dendritic synapses is greater when the time interval between the pulses is 0 than when it is 2 msec; (b) both the actual values of probabilities and their differences are generally larger for smooth than for irregular background activity; and (c) the difference is greater the closer together the two synapses. 48 pp. Ref. (Author)

RM-5691-PR Prerequisites for Chemical Thermodynamic Models of Living Systems. J. C. DeHaven. November 1968.

A discussion of the mathematical techniques and physicochemical concepts involved in the construction of certain types of biological models for use in computer simulation. The basic tools employed are a mathematical method and a computer program to calculate the composition of multiphased chemical systems, given the values of certain combinations of state-determining parameters (chemical inputs, temperature, pressure). A steady-state approach is used because the scientific basis of thermodynamics is better developed than that of kinetics, the mathematical treatment is easier, and many biological systems are either in or closely approach steady states in their chemical composition. Selection of a physiological function or subsystem to be investigated depends on (1) the availability of technological tools; (2) established data; (3) whether it is conveniently factorable from a larger system so that it can be studied over a range of conditions when removed from its normal environment; (4) no feedback effects as a result of changes in the subsystem. An illustrative model of respiratory gases interacting with an aqueous phase is constructed. 137 pp. Refs. (EB)

RM-5722-PR A Flight Planning Model for the Military Airlift Command. J. L. Midler, R. D. Wollmer. October 1968.

An analytic approach to Military Airlift Command (MAC) flight scheduling that takes account of the uncertainty present in cargo requirements or demands confronting MAC. The approach consists of two related models: (1) a monthly planning model that produces an initial schedule and (2) a daily model for making periodic changes in the schedule. The monthly model determines the number of flights—channel and special assignment airlift—for each type of aircraft in the MAC fleet. In the daily model, the principal variables are the number of aircraft of each type to switch from one route to another and the number of commercial flights on spot contract to add on the current day. A detailed mathematical description of each model and its physical interpretation is given. 36 pp. Refs. (LK)

RM-5759-PR TACTICS: A Three-Body, Three-Dimensional Intercept Simulation Program. J. H. Hutcheson, R. Segerblom. October 1969.

TACTICS is a computer program written in FORTRAN IV which mathematically simulates the dynamics of flight in three-dimensional space of as many as three vehicles simultaneously. The purpose of the Memorandum is to acquaint users with the capabilities and basic theory of the program and to serve as a reference manual for those who wish to use the program. The first part of the Memorandum describes the theory of operation and is oriented toward those with a mathematical or technical background. The second part is concerned with how to use the program, i.e., how to provide input data, select options, and develop a flight program. A number of illustrative examples of a wide variety of problems are given in detail, including data and FORTRAN listings. In many cases it should be possible to set up a specialized problem by modifying or combining various features of the examples. 188 pp. Refs. (Authors)

RM-5769-PR A Heuristic Scheduling and Resource Allocation Model for Evaluating Alternative Weapon System Programs. J. D. Wiest. August 1969.

Description of a model designed to help decisionmakers more realistically appraise the scheduling implications of alternative weapon system programs. Most widely used models for program planning and scheduling do not take into account the problem of resource availability, although many important resources are limited and constrain the scheduling of activities that require them. SPARTAN, a computer model programmed in FORTRAN IV, is specially designed to address the problem of evaluating alternative weapon system proposals given limited resources. Heuristics or scheduling rules modify the basic computer program to increase the utilization of available resources or shorten the length of the schedule. Results from a test case indicate that a resource-constrained model can yield more realistic costs and completion dates, as well as different choices among development strategies, than a model that assumes unlimited resources. 103 pp. Refs. (CC)

RM-5776-PR The SIMSCRIPT II Programming Language: Reference Manual. P. J. Kiviat, R. Villanueva. October 1968.

A compact reference listing of the syntax and semantics of SIMSCRIPT II, designed for professional programmers already familiar with the language. (SIMSCRIPT II is fully described in R-460, and its IBM 360 implementation in RM-5777.) The notation employed was chosen for convenience and descriptive power from conventions previously used in computer programming language descriptions. The study describes notation; basic constructs (symbols, primitives, metavariables); statements (nonexecutable, storage allocation, computation, control, input-output, simulation); system-defined values (constants, variables); a system-defined routine (the ORIGIN routine for simulation time); generated attributes, variables, and routines; and library functions. 32 pp. (MW)

RM-5777-PR The SIMSCRIPT II Programming Language: IBM 360 Implementation. P. J. Kiviat, H. J. Shukiar, J. B. Urman, R. Villanueva. July 1969.

A supplement to the user's manual (R-460), this Memorandum describes the implementation of SIMSCRIPT II on Rand's 360/65 computer. The error codes issued during compilation and during execution are listed and their meanings explained. The first section of this manual contains modifications to R-460 and can only be used in conjunction with it; it identifies the statements that are not yet implemented. Other sections give the rules and deck setup for compilation, assembly, and execution; ways to define additional data sets; calling assembler language routines; storage allocation during execution; random number generation and statistical functions; and directions for installing the compiler, including a

listing of JCL that can be used to load the library, compiler, and assembly interface and to punch off the SIMSCRIPT II macros, distributed procedures, and sample program. 52 pp. (See also RM-5776.) (MW)

RM-5809-NIH Ionic Interactions between Neural and Nonneural Membranes in the Mammalian Central Nervous System. R. M. Lebovitz. December 1969.

In this study, it is shown that the hypotheses of (1) the ionic basis of neural electrical activity and (2) a restricted extracellular space, imply transient, local depolarization of otherwise resting membranes by spike activity in a nearby active neural membrane. The depolarization is mediated by variations in the extracellular concentration of potassium ion, which leads it to be called an ionic interaction. A model describes the dynamics of a limited extracellular volume, and derives flux equations for the electrochemical movement of potassium ion to and from the extracellular space. The calculated magnitudes for the postulated interaction are impressive; in particular configurations, the interaction may exceed firing level and communicate an action potential across the extracellular space. Although this interaction has not yet been experimentally verified, sufficient data suggest its existence. It should help to understand such phenomena as presynaptic control of information and membrane noise, and could relate to more permanent information storage, as well as certain pathological states. 63 pp. Bibliog. (CC)

RM-5810-PR Emission Rates in Thermionic Diodes. C. Y. Fleck. June 1969.

The derivation of a new expression for the free area function for translation of absorbed particles in the study of the surface physics of thermionic diode electrodes. A relatively new theory involves direct energy conversion through utilization of thermionic emission of electrons from a hot metal. This Memorandum studies the surface effects that control emission rates in a totally different way. Using a digital computer, the surface migrations of particles absorbed on a surface are simulated. The simulation incorporates relevant geometrical and energetic considerations as realistically as possible, and calculates the free area for translation by a Monte-Carlo process. When the resulting expression for free area is used in calculations, a substantial improvement can be seen in the agreement between predicted and measured emission rates. 89 pp. Refs. (KB)

RM-5821-PR C-130E Tactical Airlift Capability: COMBAT SAMPLE Simulations. T. C. Smith, S. H. Miller, P. A. Mason. January 1969.

An analysis of tactical aircraft capability based on SAMSOM II simulations of actual C-130E operational data, for Project COMBAT SAMPLE. Demonstrated capability ranges from 5.4 to 6.3 hours per aircraft day. Simulations suggest that the higher figure could be attained at the cost of (1) severe degradation of missions, (2) virtual elimination of reserve capability, and (3) a shortage of maintenance specialists. Elimination of residual emergency aircraft in favor of higher utilization imposes value-judgment problems on airlift managers. To aid them, simulations can construct tradeoff curves that permit comparison of various utilization capabilities with corresponding residuals. The shortage of maintenance specialists could be alleviated by (1) spreading maintenance personnel among the main operating base and forward operating locations and (2) balancing crew chief and specialist manpower spaces. Estimates of wartime airlift capabilities depend on many interrelated factors, including utilization and ACL, available aircraft, resource mix, and priority requirements. 67 pp. Bibliog. (CD)

RM-5822-PR Maximum C-130E Tactical Airlift Capability: COMBAT SAMPLE. S. H. Miller, J. S. Hamilton, P. A. Mason. January 1969.

An analysis of C-130E tactical airlift capability for various types of intratheater airlift operations. Using COMBAT SAMPLE data and assuming no resource or operational constraints, an analytic model is used to compute the maximum capability (in flying time per aircraft per day) of a squadron flying four different tactical airlift missions. For scheduled, or oncall, random request operations (considered the most typical), the Air Force planner can expect no more than 5.6 flying hours per C-130E per day; for austere, preplanned operations, about 7.3; and for area support operations, about 6.3. A SAMSOM II simulation model is used to determine how maximum airlift capability is affected by reducing direct maintenance manpower. Simulations show that 500 to 625 assigned maintenance men would allow maximum capability; 400 to 435, 90 to 98 percent; 225 to 255, 60 to 70 percent; and with 100 assigned maintenance men, a squadron of 16 aircraft could achieve only 10 to 25 percent of its maximum capability. 72 pp. Refs. (See also RM-5821.) (CD)

RM-5829-PR Primal Resource-Directive Approaches for Optimizing Nonlinear Decomposable Systems. A. M. Geoffrion. December 1968.

The optimization of large systems comprised of interrelated subsystems is considered. Three different methods are presented for decentralizing the optimization by partitioning into subsystems and iteratively allocating resources to the subsystems, followed by a coordination procedure. The Tangential Approximation method builds up a piecewise-linear approximation to the optimal response functions based on the optimal multipliers that become available at each iteration. These multipliers are also used by the Large-Step Subgradient approach, which extends a typical large-step gradient method to cope with the non-differentiability of the response function. An explicit linear program is derived for finding the feasible direction yielding the greatest rate of increase in the maximand. The Piecewise approach exploits the relative simplicity in the linear and quadratic cases of the optimal response functions and uses improving feasible directions to guide the transitions between regions of simplicity. All can be used with price-directive procedures, but resource-directive optimization has the advantages of primality. 66 pp. Refs. (MW)

RM-5859-PR Maximum-Likelihood Prediction and Estimation for Nonlinear Dynamic Systems. L. D. Attaway. December 1968.

A method for determining the system state using noise-corrupted observations of a non-linear dynamic vector process, with a numerical application to radar observation of a reentry body. The study examined the feasibility of numerically solving the vector-differential equations satisfied by the maximum-likelihood estimator. The maximum-likelihood estimate is that initial condition which minimizes a certain functional on itself, on the observation, and on the 2a priori statistics. This functional describes an m plus 1 surface at time T, the upper time limit of observation; the desired estimate corresponds to its minimum. A differential equation is developed governing the evolution of this estimate with time T. Using the differential equation, the algorithm calculates as a function of T that maximumlikelihood solution that evolves over time from the unique solution at time T = O (given by the 2a priori mean vector). Differential-equation solutions with and without Newtonian techniques (for constant T) were used to estimate reentry-vehicle initial conditions for a simulated reentry. One coordinate time rate (initial angle) was not measured and served as an unknown parameter with 2a priori statistics. The estimates converged to within the order of the Cramer-Rao conditional bound. The unknown parameter was handled as successfully as the others. Computation with readily available programs and a general purpose computer resulted in processing times considerably greater than real time. Special-purpose computers with efficient programs can be expected to reduce computing time to on-line, real-time realization. 102 pp. Refs. (MW)

RM-5866-PR Digital Computer Simulation: Estimating Sample Size. G. S. Fishman. August 1969.

An algorithm for automatically estimating and collecting the sample size required for statistical precision in a computer simulation experiment while the simulation is running. The algorithm, which would be incorporated directly into the computer routines, would relieve an investigator of the burden of first estimating the variance of the sample mean from a data sample obtained from a trial run, then estimating the sample size necessary for the specified confidence interval, and finally collecting that many more observations in a successive simulation run. The underlying probability model is autoregressive: it would depend on an autoregressive representation of the sequence that considers each observation as a linear combination of past observations plus an uncorrelated random residual. This approach need not require more than 4 or 5 autocovariance computations to estimate the variance of the sample mean. A flowchart is included to aid in building the technique into simulation programs. 61 pp. Refs. (MW)

RM-5870-ESSA Numerical Models of a Tropical Cumulus Cloud with Bilateral and Axial Symmetry. F. W. Murray. November 1968.

Comparison of two versions of a numerical model for cumulus convection. One version is symmetrical about a vertical plane; the other, about a vertical axis. It is found that the axisymmetric model grows more vigorously than the other in both speed and strength of development, but more realistically represents the relations between downdraft and updraft. The model, at least with the eddy exchange coefficients used, was found to be deficient in necessary turbulent entrainment. The 1963 findings of Ogura's experiment are generally confirmed but also extended. Further study is suggested on the effects of different initial impulses on cloud growth. 38 pp. Refs. (See also RM-5564-NRL, RM-5582-ESSA.) (KB)

RM-5883-PR Digital Computer Simulation: Computer Programming Languages. P. J. Kiviat. January 1969.

A discussion of simulation languages, their characteristics, the reasons for using them, and their advantages and disadvantages relative to other kinds of programming languages. Simulation languages are shown to assist in the design of simulation models through their world view, to expedite computer programming through their special purpose, high-level statements, and to encourage proper model analysis through their data collection, analysis, and reporting features. Ten particularly important simulation programming language features are identified: modeling a system's static state, modeling system dynamics, statistical sampling, data collection, analysis and display, monitoring and debugging, initialization and language usability. Examples of each of the four simulation languages, GPSS, SIMSCRIPT II, SIMULA, and CSL, are used to illustrate how these features are implemented in different languages. The future development of simulation programming languages is dependent on advances in the fields of computer languages, computer graphics, and time sharing. Some current research is noted, and outstanding research areas are identified. 110 pp. Refs. (MW)

RM-5893-RC Analytic Hospital Planning: A Pilot Study of Resource Allocation Using Mathematical Programming in a Cardiac Unit. R. M. Gurfield, J. Clayton. April 1969.

A description of RAPS (Resource Allocation for Patient Services), a new technique for planning medical facilities. RAPS applies input-output analysis of patient flow and uses standard linear programming algorithms to match clinical facilities against demand. Conventional hospital planning techniques take no account of the fact that different kinds of patients use different amounts and mixes of services, so that overcrowding and inadequacies commonly result, while some facilities may be underutilized. RAPS is based on the principles that (1) all patients can be classified into a finite number of functional groups, based on diagnosis; (2) each procedure that uses a different mix of space, personnel, and equipment is a functional facility; (3) different groups of patients follow different paths through the facilities and require different mixes of services; (4) all services to patients can be expressed in terms of the flow of patients through facilities; (5) within each patient group, the average utilization of each service constitutes the patient-service vectors of that group for computing purposes. The bulk of the Memorandum consists of a sample RAPS analysis of the inpatient cardiac care service at UCLA Medical Center. 92 pp. Refs. (MW)

RM-5925-NIH An Interactive Graphics Program for Studying Models of Kinetic Chemical Systems. G. F. Groner, R. A. Berman, R. M. Heirschfeldt. June 1969.

This interactive computer graphics system permits biologists to study models of kinetic chemical systems and computer scientists to investigate interactive modeling. The program runs on an IBM 360/Model 40 computer and is intended to provide a convenient means of (1) describing a model via chemical equations; (2) observing the behavior of a model during simulation; (3) editing output formats and modifying the model. The user communicates with the computer via the RAND Tablet used in conjunction with a 2250/Model 1 CRT display device. The program has several desirable features: (1) It simulates multiphase chemical systems having both fast and slow reactions. (2) The user may enter chemical equations by printing them, as on a piece of paper, and the program displays its interpretation as a check. (3) The user can intervene in the simulation at any time, examine any reactant plotted on any linear scale against any other reactant or time, rescale curves, or delete them. (4) A reset capability permits backtrack for correction or to return a graph to a previous state. 62 pp. (MW)

RM-5932-NRL Humidity Augmentation as the Initial Impulse in a Numerical Cloud Model. F. W. Murray. 27 January 1969.

Discussion of the use of an initial humidity impulse (instead of temperature impulse) in numerical cloud modeling. Experiments use a perturbation of relative humidity to trigger the convection process in an axially symmetrical numerical model of a cumulus cloud. Study of the effects of varying the width and depth of the perturbation shows that the width of the simulated cloud is influenced by the width of the impulse, and its rate of growth and ultimate depth mainly by the depth of the impulse. The initial impulse is an artifice required to start the model. If care is taken not to add large amounts of potential energy in the initial impulse, realistic simulation of cumulus convection can be achieved. (See also RM-5316, RM-5564, RM-5582-1, RM-5870.) 38 pp. Refs. (CD)

RM-5937-PR A FORTRAN Programmer's Introduction to SIMSCRIPT II. H. J. Shukiar. March 1969.

This study is intended to introduce the FORTRAN programmer to some of the main concepts and features of the first three levels of SIMSCRIPT II—the levels which constitute an algebraic compiler. Emphasis is on the power and flexibility that SIMSCRIPT gives the programmer. Among the distinctive features are (1) the SIMSCRIPT preamble; (2) the preamble statements, such as NORMALLY, DEFINE, DE-FINE TO MEAN; (3) the fact that any number of conditional expressions can be executed if a logical condition is met; (4) the ability to reread the same records in different formats. Unlike FORTRAN, SIMSCRIPT passes argument values rather than argument locations between subprograms. The method of constructing arrays is radically different. The SIMSCRIPT programmer can conserve core storage, construct ragged tables, generate tree structures, and do list processing with relative ease, and his programs can be read rather than deciphered. 35 pp. (MW)

RM-5940-PR A Model for Targeting Strikes in an LOC Network. R. D. Wollmer, M. J. Ondrasek. September 1969.

A computer model for developing and evaluating a targeting strategy against an opposing force's lines of communication. This aim is to obtain the greatest reduction in enemy throughput and the greatest time and cost of repair. The network arcs (road, rail, or waterway segments or transshipment points) are characterized by beginning and ending nodes, upper and lower bounds, interdicted and uninterdicted unit flow costs, repair times and costs, and the probabilities that attempted strikes are successful. The model is programmed in daily cycles, with the user specifying number of days and strikes. Strikes are targeted one by one. At the end of each strike, total LOC throughput and costs are printed out; if desired, a detailed status report and/or a profile of total flow versus user cost are also output. The FORTRAN program is thoroughly selfdocumented. 54 pp. Refs. (MW)

RM-5949-PR A Programmer's Guide to VIMCOS. O. M. Hixon, B. G. Marks, R. J. Moulenbelt, F. Valadez, R. E. Stanton. October 1969.

A detailed description and directions for using all the routines of VIMCOS (Vehicle for Investigation of Maintenance Control Systems), an on-line, real-time game simulation model that allows an airbase maintenance controller to select and schedule workloads. VIMCOS comprises an aircraft maintenance control system and an environmental simulator; both operate within the general computer-support system composed of a supervisor (written in assembler language), functional routines, display routines, information retrieval routines and the data base. Together they enable a controller to receive event notices, get further information, make scheduling decisions, and have the system play out the consequences of the decisions. Although written in PL/1, VIMCOS uses the entities-attributes-sets framework of SIMSCRIPT. The entities include aircraft malfunctions (up to 100), aircraft (up to 25), work centers (up to 10), and resources. The basic design concepts of VIMCOS and its operation in a laboratory context are described in RM-6036. 196 pp. Refs. (MW)

RM-5955-NIH Theoretical Evaluation of a Patient-Artificial Kidney System Using the Kiil Dialyzer. M. B. Wolf, P. D. Watson, B. H. Barbour. April 1969.

A mathematical model of hemodialysis (artificial kidney treatment) that can accurately predict the changes in distribution of urea and creatinine in the patient's body during dialysis, for a wide range of system parameters. The model was validated using considerable clinical data from two patients, plus one-time data from 10 randomly chosen patients on the Kiil Dialyzer. The predicted fraction removed during dialysis was plotted as a function of blood-flow rate, length of dialysis, initial blood concentrations, and patient weight. Results suggest that in most dialysis patients, material removal during dialysis and blood concentrations afterward can be accurately predicted from just the patient's weight and his rate of blood flow into the dialyzer. The computer-generated results can be valuable to the clinician by showing the time needed to dialyze a given patient to achieve a desired result. 46 pp. Refs. (KB)

RM-6036-PR VIMCOS: A Vehicle for the Investigation of Maintenance Control Systems. O. M. Hixon, B. G. Marks. October 1969.

A description of the basic concept and operation of VIMCOS, an online, realtime game-simulation model that allows a player to function as an Air Force base maintenance controller to select and schedule workloads. Part of the LP-IV study, VIMCOS is made up of the management control information system segment of CAMCOS (see RM-5255), plus an environmental simulator that represents the flow of information from remote input/output terminals in a real-world computerized maintenance control system. The controller at his console receives notices of aircraft landings, malfunctions discovered, job starts and ends, and failures to maintain schedules. He may query the system for other information on resources and needs; this information is displayed for him immediately. The model is decision-oriented. The controller makes all the decisions and the system plays out the results, keeps all the records, and creates the notices and displays. Programming details are given in RM-5949. 54 pp. Refs. (MW)

RM-6049-PR SCAM: A System Support Cost Analysis Model. R. J. Kaplan, J. Y. Lu, R. M. Paulson. November 1969.

A description of a computer model designed to assist Air Force planners during the provisioning process, which includes the requirement that every item in a weapon system be evaluated to determine (1) if it should be a spare part, and (2) if and where it should be repaired. SCAM examines four source and maintenance coding alternatives: repair at base only, repair at depot only, repair at both base and depot, and discard. The aggregate cost estimates represent total resource requirements for each alternative for a specified performance level. Through the use of optimal stock leveling policies these comparisons have the attribute of equal performance characteristics or equal resource requirements which reduce the ambiguities of earlier decision models. SCAM can also be useful in analysis of on-going systems to estimate the relative costs of any proposed change in the maintenance posture. Sensitivity analyses investigating relationships of various parameters can give a broader picture on which to base repair level decisions. The appendixes contain examples of output and the complete JOSS and FORTRAN IV programs for model operation. 96 pp. Refs. (MT)

RM-6073-PR Simulation of the Renal Effects of Antidiuretic Hormone (ADH) in Man. J. C. DeHaven, N. Z. Shapiro. November 1969.

A biomathematical model incorporating the actions of antidiuretic hormone on urine flow and composition. Body compartments representing intracellular and interstitial fluid, as well as plasma, red cells, and respiratory volume, are simulated. Urine formation, including concentration ratios produced by the kidney through glomerular and tabular functions, is treated via a compartment separated from the body by an active membrane. The composition and rate of urine flow are influenced both by the level of antidiuretic hormone in plasma and by the chemical reactions within and between body compartments, including urine. During dynamic response to stress, the current antidiuretic hormone level in the model is established by the previous history of hormone production, by excretion and destruction, and by the current plasma volume. The validity of the model was tested by simulating rapid ingestion of water. A previous model is described in RM-4609. 69 pp. Refs. (Authors)

RM-6081-PR The Pilot Training Study: A User's Guide to the PILOT Computer Model. L. Littleton. December 1969.

A detailed description, with flowcharts and listing, of the computer program for a pilot flow simulation. Given the number of trained pilots required over a time period, and a statement of the policy concerning the flow of pilots between desk and flying assignments, the computer program determines at what times and in what numbers pilots must enter and leave training courses. Requirements for a maximum of 20 years, 80 weapon systems, and 3 pilot types can be processed. PILOT can estimate the effects of alternative policies on pilot flows, and the effect of these flows on training rates. Combined with cost and resource models of the training activities, it may be used to estimate the overall impact on costs of pilot training alternatives. 73 pp. (See also RM6080, RM-6082 through RM-6087.) (MT)

RM-6082-PR The Pilot Training Study: Precommissioning Training. J. W. Cook. December 1969.

An analysis of the student flows, supporting resources, and costs of graduating pilot condidates from the 3 major sources of enrollees: Air Force Academy (AFA), Reserve Officer Training Corps (ROTC), and Officer Training School (OTS). By developing estimating relationships and predictive factors from a calculation of attrition rates and historical costs of training at past student load levels, estimates can be made of the future costs of training at different levels. For 1973 it is estimated that the AFA will supply 645 pilot candidates at an annual cost of $37.8 million (in 1968 dollars), while ROTC pilot candidates should number 1600 with a program cost of $12.5 million. (Because of the number of pilots produced by OTS is not consistently related to total number of graduates, it is not possible to predict the 1973 output of pilot candidates from OTS.) The marginal cost of producing each additional pilot candidate is estimated to be $28,550 for AFA, $3700 for ROTC, and $2700 for OTS. 92 pp. (See also RM-6080, RM-6081, RM-6083 through RM-6087.) (MT)

RM-6083-PR The Pilot Training Study: A Cost-Estimating Model for Undergraduate Pilot Training. S. L. Allison. December 1969.

A computer model for estimating the resources required and the costs for any given configuration of the USAF undergraduate pilot training system. The model can be used to measure the effects of alternative policies and conditions, such as changes in required number of graduates, in course syllabus, and in training facilities. Inputs are data specifying the number of UPT graduates required, course syllabus requirements, instructor-student ratios, number of aircraft and simulators available, aircraft and simulator utilization rates, facilities available, and cost relationships. Outputs are the manpower, equipment, and facilities required for the described program. The model incorporates three costing concepts basic to most military costing studies: (1) analysis based on incremental costs; (2) all categories of cost included in the incremental cost computation; (3) no cost amortization. The model can be used independently or with other pilot training models. Appendices describe the Survival School model and list the FORTRAN IV and JOSS programs for it. 113 pp. Bibliog. (See also RM6080 through RM-6082, RM-6084 through RM6087.) (MT)

RM-6084-PR The Pilot Training Study: A User's Guide to the Undergraduate Pilot Training Computer Cost Model. L. Littleton. December 1969.

A description of the program, overlay structure, input deck, and the output of the UPT computer model, which will estimate requirements for manpower, supplies, equipment, services, and facilities of the undergraduate pilot training system and the costs of these resources. Options are provided for estimating current or long-range costs of existing programs or the impact that virtually any program change will have on required resources and costs. Input is by card and output is printed. There are 3 options: (1) 11 tables of information on student loads, base capabilities, the UPT program, manpower, aircraft, and simulator requirements for each base, and costs, by base and not assignable to base, by phase and not allocated to phase, and for all bases by type, by base, and by phase; (2) the values of all the variables including those in the 11 tables; and (3) only the variables associated with facilities. The program flowchart and listings of the program input data elements and of the

FORTRAN IV computer program are appended. 211 pp. (See also RM-6080 through RM6083, RM-6085 through RM-6087.) (MT)

RM-6085-PR The Pilot Training Study: Advanced Pilot Training. P. J. Kennedy. December 1969.

A description of the general framework and complexities of formal training courses in terms of types of aircraft, organization and mission areas, bases, and commands. Formal training is provided for 52 types of aircraft by five commands in six different mission areas. In general, pilots qualify to operate a specific aircraft and to fly a particular mission by completing the prescribed formal course as listed in the USAF Formal Schools Catalog (AFM 50-5). Courses cover both ground and flying training and last from 2 to 31 weeks. They are designed to fit student qualifications and experience; conversely, student-selection criteria must be compatible with the demands of the course. In estimating the resource requirements for planning and budgeting, the analyst must first identify all of the resources contributing to pilot training and then distribute the studentpilot resources consumption among individual student pilots to show how changes in student strength affect resource requirements. 59 pp. Bibliog. (See also RM6080 through RM-6084, RM-6086, RM-6087.) (MT)

RM-6086-PR The Pilot Training Study: A Cost-Estimating Model for Advanced Pilot Training. L. F. Knollmeyer. December 1969.

A description of the structure of the APT model and the problems encountered in its development. The model is designed for estimating the required resources and costs of training pilots to fly more than 50 different types of USAF aircraft. The model consists of detailed statements, in logical sequence, of the relationships among factors significantly affecting training costs, such as the relationship between numbers of students and instructors. These relationships are incorporated in a computer program, which, when given the appropriate inputs, e.g., students, aircraft type, and course length, calculates the incremental time-phased requirements for personnel, equipment, and services and their associated costs. Resources and costs are computed by weapon system on an annual basis. The model may be used for any number of weapon systems and years. Results of general interest are output in a standard table, but any or all inputs and outputs may be made available, optionally, for analysis. Total operating cost, incremental investment cost, and operating cost per graduate are computed. Resource requirements include personnel, aircraft, and simulators; facilities are excluded. 93 pp. (See also RM-6080 through RM-6085, RM-6087.) (MT)

RM-6087-PR The Pilot Training Study: A User's Guide to the Advanced Pilot Training Computer Cost Model (APT). H. E. Boren, Jr. December 1969.

A description of the general flow of operations, input procedures, and output options of the computer program for the APT model whose methodology is described in detail in RM-6086. The computer will process as many runs as desired, each run consisting of one or more weapon systems for one or more years of operation. Within a run, once a complete set of inputs has been entered for the first year of the first weapon system, only changes in those inputs need be entered for succeeding years and systems. Relevant resources and costs are calculated for each year and are printed in prescribed formats. In addition, two optional printouts of the values of the variables are available. The program is written in FORTRAN IV for the IBM 360/65 using no auxiliary programs. The flowcharts and listings of the program and the program variables are appended. 91 pp. (See also RM-6080 through RM-6086.) (MT)

RM-6093-PR Numerical Prediction of the Thermodynamic Response of Arctic Sea Ice to Environmental Changes. G. A. Maykut, N. Untersteiner. November 1969.

Description of a one-dimensional model of Arctic sea ice. The inputs are: albedo, incoming radiation, turbulent fluxes, oceanic heat flux, ice salinity and snow accumulation. Given an arbitrary initial ice temperature field and ice thickness, the model predicts the changes in these wrought by specified environmental parameters. Annual variations in temperature and thickness are followed year by year until the pattern is stable, i.e., until either the ice disappears or the annual sequence of growth and depletion is repeated unchanged. Values predicted (using inputs based on the present climate) agree closely with field observations. Tables for 28 specified cases and annual charts for 25 are presented. In addition to showing annual growth and depletion of ice under normal and anomalous climates, results show mechanisms by which environmental conditions affect the ice. 189 pp. Refs. (See also R-444, RM-5233, RM-5793.) (Author)

RM-6110-RC The Effects of Western Coastal Orientation on Rossby-Wave Reflection and the Resulting Large-Scale Oceanic Circulation. W. L. Gates. August 1969.

The effect of the orientation of the western shore on the structure and behavior of large-scale currents in a homogeneous wind-driven ocean of uniform depth is investigated through time-dependent numerical integrations of a primitive dynamical model. These solutions are shown to consist primarily of transient Rossby waves reflected from the western shore, whose characteristics correspond well with the results of linear inviscid theory during the earlier portion of their life cycle. The reflection of the waves' group velocity appears to determine the location of maximum current variability in the western part of the basin. The western boundary current is weakened with increasing deviation of the western coast from a north/ south orientation, while the strength of the countercurrent is not. 54 pp. Refs. (KB)

RM-6112-PR Computer Graphics for Simulation Problem-Solving. T. E. Bell. December 1969.

A description of the use of interactive computer-graphic analysis in simulating, and then designing and developing, Rand's Video Graphics System, which will provide low-cost, high-capability, responsive, graphic computer access to many users simultaneously. Simulation began before the system was fully defined, as an aid to design. The graphic displays were presented on an IBM 360/40; the user entered data via the RAND Tablet. Of the three types of display—Statistics, Variable Graph, and Gantt Chart—the latter was used most. Graphic analysis cut total modeling time approximately in half. Since much hard copy was pasted into strip charts, these should be produced automatically. Graphics capabilities facilitated analysis of a large volume of simulation output to examine the model in detail and to discover anomalous behavior; ongoing simulation proved a valuable aid to design. 28 pp. Bibliog. (MW)

RM-6132-NASA ECSS: An Extendable Computer System Simulator. N. R. Nielsen. February 1970.

Describes the major design features of ECSS, a programming language for simulating computer systems as an aid to design and evaluation. In its prototype version, ECSS is implemented as a translator into SIMSCRIPT II with extensions to add further capabilities. ECSS can model floworiented as well as discrete-event simulations, having added to SIMSCRIPT the SIMULA-like process, which is both an entity and an event subroutine, and the HOLD UNTIL and WHEN TRUE statements. The emphasis throughout is on ease of use, freedom in modeling, and on minimizing programming and debugging time. Standard features can be simulated merely by requesting the facilities and inputting data; for nonstandard features, the user writes his own description in SIMSCRIPT and uses as much as he wishes of the ECSS facilities. Unused facilities do not affect execution. Implementation of the ECSS translator is now under way. 53 pp. Ref. (MW)

RM-6203-PR Whole Body Base Excess: Acute Response to Acid-Base Stress in the Dog. C. D. Russell, H. D. Roeher, M. M. Illickal, E. C. DeLand, J. V. Maloney. May 1970.

Derives the correlation between the arterial blood composition and the acid-base status of the whole body subjected to simultaneous respiratory and metabolic changes. To improve diagnosis and therapy, the biochemical status of a patient is often predicted from commonly measured parameters of a sample of blood 2in vitro. This method gives a rough index of the body status. This memorandum constructs a nomogram for more exactly estimating whole body base excess from the pH and the partial pressure of carbon dioxide of arterial blood in vitro. It is based on experimental data obtained from 54 nephrectomized dogs subjected to hyperventilation, carbon dioxide breathing, and infusion of acid and base. The experimental results validated a mathematical, computer-based model of whole body fluid and electrolyte distribution. Because

of the similarity between the acid-base responses of dog and man, the model should permit more accurate determination of human whole body base excess from a blood specimen. 40 pp. Ref. (LC)

RM-6210-ARPA Studies in Climate Dynamics for Environmental Security: A Note on the Lateral Eddy Viscosity Due to Transient Rossby Waves in a Barotropic Model. W. L. Gates. April 1970.

Simulation of a wind-driven homogeneous ocean and its characteristic circulation. From time-dependent numerical solutions of the model, a negative lateral eddy viscosity is estimated in the basin interior, where flow is dominated by transient Rossby waves. These waves produce a systematic meridional convergence of eddy momentum into the latitudes of mean eastward current and are analogous to the Rossby waves in the general circulation of the atmosphere. This regime exists in spite of the formally prescribed lateral viscosity in the model's equations; the required viscous dissipation apparently occurs in the standing waves of the western boundary current system. Results suggest that a strong gradient of the effective eddy viscosity may be characteristic of an ocean with meridional boundaries. This investigation was begun as part of an effort to evaluate the effects of environmental perturbations that could be detrimental to the security and welfare of our nation. 22 pp. Ref. (See also RM-6110, RM-6211.) (KB)

RM-6211-ARPA Studies in Climate Dynamics for Environmental Security: Numerical Studies of Transient Planetary Circulations in a Wind-Driven Ocean on the Sphere. W. L. Gates. April 1970.

A numerical investigation of a bounded ocean basin on the spherical earth, with particular attention directed to the role of planetary circulations. The time-dependent primitive equations are solved for a shallow, wind-driven, homogeneous ocean in a basin of uniform depth on the sphere. In a series of comparative numerical solutions, it is shown that at least a 2-deg resolution is needed to resolve the western boundary currents adequately and to avoid undue distortion of the transient Rossby waves. Although the transient Rossby waves systematically produce a momentum flux convergence at the latitude of the maximum eastward current, this is only a relatively small contribution to the zonal oceanic momentum balance; the bulk of the mean zonal stress is balanced by a nearly stationary net pressure torque exerted against the meridional boundaries by the windraised water. 62 pp. Ref. (RG)

RM-6214-NIH Convection and Diffusion in the Microcirculation. J. Aroesty, J. F. Gross. June 1970.

A study using the ideas and analytical techniques of fluid mechanics to investigate the role of plasma motion in the transport of species between erythrocytes and surrounding tissue in rather narrow capillaries. It has been widely believed that the plasma circulatory motion in the region between the red blood cells and capillary wall is sufficiently vigorous to augment the low rates of species transport by diffusion alone. This study makes a detailed theoretical and numerical examination of the bolus model of capillary flow. It shows that for this highly idealized situation, the convective motions of the plasma and the enhanced mixing due to these motions do not appreciably augment diffusional species-transport rates for dissolved gases. The results of the equations of motion and the equations of species transport indicate that plasma mixing is important only in the transfer of materials such as macromolecules, which may diffuse more slowly than dissolved gases. 55 pp. Ref. (DGS)

RM-6224-PR An Application of Computer Graphics: The FAST-VAL Ground Unit Deployment Input System. N. D. Cohen. April 1970.

Describes the benefits of interactive computer graphics to FAST-VAL. Interactive graphics facilitates and therefore reduces the errors in deployment of resources for this complex model. An interactive program permits the user, seated at a CRT console, to enter new data and to study or even modify the program while it is running. The FAST-VAL Ground Unit Deployment Input System was designed to use an IBM 2250 graphic console attached to an IBM 360/50 computer. The console displays a grid representing an area divided into 100-ft squares. The interactive system enables the user to create and deploy resource symbols, to move them freely around the grid, and to delete them by pressing one of eight lighted function keys: LABEL, SYMBOLS, SELECT, DEPLOY, DELETE, CONVERT, RESTART and QUIT. 96 pp. Ref. (LC)

RM-6230-RC A Water Quality Simulation Model for Well-Mixed Estuaries and Coastal Seas: Volume I, Principles of Computation. J. J. Leendertse. February 1970.

Detailed description of a model of assessing technical alternatives in the management of fluid waste discharges in wellmixed estuaries and coastal areas. A model is developed from the numerical integration of (1) flow equations that simulate the water movements of tides and (2) the advective diffusion equation representing the movement of dissolved waste constituents. Partial differential equations that formulate the two-dimensional movement of waste constituents are approximated by two difference equations; these equations are used in succession for a step-by-step solution in time. Computational procedures are tested on models of Jamaica Bay, Long Island, New York. A model with a computational grid size of 500 ft was used for the computation of tide levels and velocities in this shallow bay with many tidal flats. 78 pp. Ref. (KB)

RM-6256-PR Tracking Error Propagation and Orbit Prediction Program. R. Mobley, L. N. Rowell, M. C. Smith. July 1970.

Description of TEPOP (Tracking Error Propagation and Orbit Prediction Program), a Rand-modified FORTRAN IV program used in the AFSC/ADC Joint Mission Analysis on Surveillance of Objects in Space. TEPOP simulates space-vehicle tracking data from as many as 54 sensors. Rand improvements: Sensors may be satellite-based, may rotate, may be limited in azimuth, elevation, and range; drag bias can be included; the JPL ephemeris tape is used; the program was converted to double-precision. Besides determining a target's path from real data, TEPOP can be used to generate synthetic data for objects orbiting earth, sun, moon, Mars, Venus, or Jupiter, or on an interplanetary course; to study the effects of introducing random and systematic errors; and to generate confidence regions for position and velocity. The reference coordinate system is automatically centered on whichever body influences the tracked object at the time. 74 pp. Ref. (MW)

RM-6268-PR FAST-VAL: Relationships Among Casualties, Suppression, and the Performance of Company-Size Units. S. G. Spring, S. H. Miller. March 1970.

Describes the secondary effects, as input to FAST-VAL simulations, of casualties, equipment losses, and fire exchange on the performance of individual combat troops. These effects—including diversion of survivors, suppression, and loss of leadership and cohesion—are calculated in terms of break and stall levels, company effectiveness, weapon-crew effectiveness, suppression of fire, movement rate, suppression of mobility, and hand-to-hand combat performance. In a FAST-VAL simulation, the percentage of surviving effective riflemen is computed as a function of the preplanned rate of fire, reserve-commitment policy, cumulative casualties, and suppression. An attacking company breaks when it has sustained 30 percent casualties; a defending company, 50 percent. The artillery, mortar, and machine-gun rates of fire are computed separately. An attacking company's forward movement ceases at 23 percent casualties; an attacking armored unit stalls with 70 percent vehicle losses. Discussion includes detailed computations for deriving the percentage of riflemen still effective. 78 pp. Ref. (LC)

RM-6279-PR JASP: A Simulation Language for a Time-Shared System. A. A. B. Pritsker. June 1970.

A combination User's Manual and Programmer's Guide for JASP, a simulation language for use on the JOSS time-shared system. Written in JOSS language, JASP provides standard routines for performing functions that are common to many simulations: initialization; time and event control; information storage and retrieval; performance data collection; summary, monitoring, and error reporting; and random deviate generation. The routines for performing each of these functions are described, as well as the specially defined JOSS variables used by JASP. The JASP framework for creating a simulation model follows that used in SIMSCRIPT and GASP. Simulations of a simple queueing system and a man-machine price and inventory system are used to illustrate areas for which JASP is designed. The Memorandum provides complete documentation and ready-reference for JASP statement types, part interactions, and JOSS coding. 128 pp. Ref. (DGS)

RM-6327-NIH BIOMOD: A User's View of an Interactive Computer System for Biological Modeling (A Preliminary Report). G. F. Groner, R. A. Berman, R. Clark, E. C. DeLand. August 1970.

An example of the current version of BIOMOD, an interactive computer-graphics system for biological modeling. The example models water and solute distribution between the intravascular and extravascular spaces of the body. BIOMOD operates on a graphic console comprising a CRT screen, RAND Tablet, and keyboard. BIOMOD allows the user to draw block diagrams, handprint or type text, push displayed buttons, and drag labels, while providing immediate interpretation and validity reports. A user may represent a model by a block diagram, each component of which may be defined by another block diagram, by CSMP statements, or when BIOMOD is completed —by chemical equations, differential equations, or data curves. Hierarchy facilitates devising complex models a portion at a time. All modeling languages used are internally translated to IBM's CSMP/360 simulation modeling language. During the simulation, the user may display curves for different variables, rescale, alter simulation parameters, and immediately rerun or continue the simulation. 46 pp. Ref. (MW)

RM-6357-PR Mathematical Models in Education and Training. A. L. Hammond. September 1970.

A nontechnical introduction to the state of the art in modeling education systems, prepared for Rand's Air Force technical training study. Input-output models are convenient for examining voluminous data on student flows for short periods or for relatively static institutions. Manpower planning models seem least useful. Optimization and simulation models are complementary: Optimization models show resource allocation choices explicitly, yield plans and priorities, and stimulate policy-level discussion. Simulations can help in management and short-term planning if enormous quantities of data are available. A model need not be realistic if it gives useful answers, nor is there one best way to model a situation. Simple models are best at our present level of understanding the educational process. Included are a review of the literature and a selective bibliography. Mathematical details are given in an appendix. 38 pp. Ref. (MW)

PAPERS

P-3036 Applications of a Digital-Computer Simulation of a Neural Network. D. H. Perkel. December 1964.

Description of a neuron model developed as an adjunct to experimental neurophysiological investigations. The computer program is described and applications of the model discussed. 29 pp. (See also RM-4132-NIH.)

P-3057 A Defense of Neural Modelling. D. H. Perkel, G. P. Moore. January 1965.

A discussion of specific instances in which neural models have proved useful to research workers in neurophysiology. The examples are presented as a response to a commentary questioning the usefulness of such models to the experimental research worker. 11 pp.

P-3063 Social Technology. O. Helmer. February 1965.

A reappraisal of methodology in the social sciences with specific proposals for modifications of traditional procedures. The Paper suggests that social scientists explore the possibilities of operations research approaches, of operational model building, and of expert opinion. It also suggests procedures in the areas of urban renewal, educational reform, political, and long-range economic forecasting. 40 pp.

P-3076 FAST-VAL: A Model for Forward Air Strike Evaluation. J. R. Lind. March 1965.

A description of FAST-VAL (Forward Air Strike Evaluation) model. The Paper outlines the rationale used in developing the FAST-VAL model, provides illustrative assessments, and suggests potential wargaming applications. 6 pp.

P-3114 A Short Course in Model Design. I. S. Lowry. April 1965.

An examination of the model-builder's way of thinking and the meaning of the terms of his trade, as well as suggested standards for evaluating his product. Basing his analysis on current models of urban land use and spatial interaction, the author discusses their use, the application of theories to them, the strategy of design, and the fitting and testing of a model. He concludes that ordinarily a client accepts from the model-builder a tool of unknown efficacy and that the tests are at best partial and indecisive. He also maintains, however, that the process of model-building is educational and its future is promising. 28 pp. Bibliog.

P-3128 Mathematical Problems Arising in Biomedical Research. R. E. Bellman. May 1965.

An examination of mathematical problems in biomedical research. Discussed are: (1) analytic problems originating in chemotherapy; (2) aspects of the heartlung complex; (3) questions initiated by cardiology; and (4) problems stimulated by current research in neurophysiology. 11 pp. Bibliog.

P-3141 Simulation Programming and Analysis of Results. A. S. Ginsberg. May 1965.

A discussion of techniques for simplifying and speeding simulations and for increasing the meaningfulness of results. General Purpose Systems Simulator II (GPSS), SIMSCRIPT, and programming by questionnaire are discussed as examples of simulation programming. 9 pp.

P-3148 The Application of Stochastic Processes to Countdown Analysis. D. S. Stoller. May 1965.

Elaboration of a finite Markov chain model of the space vehicle countdown process. The Paper carries this process further into the realms of complexity and reality, requiring use of a digital computer—but with a major distinction: the model is so complex and intricate that simulation of countdown activities is directly carried out on the computer. SIMSCRIPT is used to construct the simulation. 17 pp.

P-3194 Example of a Large-Model Simulation of the Blood Biochemical System. J. V. Maloney, Jr., J. C. DeHaven, E. C. DeLand, G. B. Bradham. August 1965.

A mathematical model of a viable blood system, outlined to demonstrate the plausibility of constructing detailed models of large biochemical systems. 32 pp. Bibliog.

P-3198 Families of Models. N. C. Dalkey. August 1965.

A discussion of an experimental family of models dealing with the planning problem for strategic nuclear war and with the problem of designing strategic nuclear forces. The set consists of a three-level pyramid of war games: (1) STROP, (2) STRIP, and (3) STRAP. STRAP is covered in detail. The author finds that families of models retain the advantages of simulation while allowing the possibility of dealing with a wide range of parameters and strategies. 31 pp.

P-3214 Man-Machine Simulation Experience. M. A. Geisler, A. S. Ginsberg. August 1965.

A general discussion of the technique of man-machine simulation or game-simulation, with particular reference to The RAND Corporation's Logistics Simulation Laboratory. System analysis techniques are explained according to their increasing degree of abstraction, from real world experiments to mathematical models. 23 pp.

P-3254 On the Control of Urine Formation. J. C. DeHaven, N. Z. Shapiro. November 1965.

A presentation of mathematical and physicochemical models of the intrinsic renal control of body water and electrolytes. On the basis of these models, Jacobian matrices are prepared, which assist in predicting local, qualitative changes in body water and electrolytes in response to various forms of chemical stress. The results obtained in specific examples compare favorably with those of reported physiological experiments. The Paper discusses the usefulness and limitations of these models, and describes various methods for introducing time into them— the

most useful being the one in which the flux of metabolites is derived from the composition and flow of urine. 109 pp. Bibliog.

P-3301 Tarlog: A Differential Ground Combat Model. E. P. Durbin. February 1966.

Discussion of the development of a family of differential combat models. Characteristics of the current model of the family, Tarlog, are described with suggestions for improvements based on insights gained in experiments. The author notes that Tarlog represents a step forward in the attempt to describe the essential elements and interactions of units in large-scale land combat. 17 pp.

P-3314 Introduction to the SIMSCRIPT II Programming Language. P. J. Kiviat. February 1966.

Presentation of the design philosophy behind SIMSCRIPT II. The Paper notes the incorporation of accumulated experiences into the programming language, describes the implementation and structure considerations, and reveals some of the language's important features and innovations. 7 pp.

P-3329 RAND's Role in Logistics Systems. M. A. Geisler. March 1966.

A brief summary of RAND's Logistics Department, its history and its structure. The Paper describes recent examples of the influence of RAND research on the Air Force, particularly the systems approach to base stockage, base maintenance analysis, and the development of simulation techniques. 12 pp.

P-3348 Development of New Digital Simulation Languages. P. J. Kiviat. April 1966.

An article prepared for The Journal of Industrial Engineering. It includes: (1) an examination of theories of simulation and modelling and programming; (2) a description of the design aims and a few language statements of SIMSCRIPT II, a second generation simulation programming language; and (3) comments on a probable future for simulation languages and simulation programming. 21 pp. Bibliog.

P-3349 Simulation Language Report Generators (or, I Hear You but I Don't Know What You're Saying). P. J. Kiviat. April 1966.

Paper prepared for the Symposium on Simulation Techniques and Languages, London, May 1966. The author discusses simulation programming languages and their particular need for specialized output statements. The structure of future simulation language report generators is predicted through descriptions of the programmers' and managers' need for reports about or from simulation models and programs. A set of programming statements that satisfy these needs is presented and related to the simulation programming languages of today and the future. The programming statements are in SIMSCRIPT II, but the use is illustrative only; they have not been implemented. Examples of the reports generated by the hypothetical statements are included in the Appendix. 25 pp. Bibliog.

P-3400 Simulation of Military Conflict. N. C. Dalkey. January 1967.

A discussion of the techniques of simulating military conflicts. Simulations are classified according to three characteristics: (1) size—number of elements or amount of detail; (2) formalization— extent to which rules are explicit or complete; and (3) analyticity—extent to which preferred or optimal solutions are computed. The four uncertainties that are encountered in evaluating weapon systems and weapons use are examined: stochastic, epistemic, strategic, and axiological. Specific models are described. 20 pp.

P-3453 Development of Discrete Digital Simulation Languages. P. J. Kiviat. September 1966.

A discussion of the history, current status, and possible future of computer languages that are used for describing the structure and dynamics of discrete-time systems. The author discusses principal features of the numerous simulation programming languages in current use and predicts eventual merger into one or two general-purpose languages that can be used to construct special-purpose simulation languages. 16 pp. Refs.

P-3455-1 A Numerical Study of Transient Rossby Waves in a Wind-driven Homogeneous Ocean. W. L. Gates. March 1967.

The primitive hydrostatic equations for a rectangular homogeneous ocean with a free surface on a beta-plane are integrated numerically for 60 days from an initial state of rest and an undisturbed depth of 400 m. A series of transient Rossby waves of approximately 2000 km length form in the central and eastern basin and undergo a well-marked life cycle as they propagate westward. The northward boundary current in the west and the countercurrents in the northwest may be identified as the first standing members of a continuing series of transients, with subsequent waves reaching progressively smaller maximum amplitudes. These transient oceanic long waves display a meridional asymmetry or tilt characteristic of a nonlinear poleward eddy transport of zonal momentum, much in the manner of their atmospheric counterparts. Neargeostatic equilibrium is maintained throughout, with the meridional Ekman flow of the order of a few centimeters per second. After a spin-up period of about 12 days, the surface potential and total kinetic energy display damped oscillations with the free period of approximately 16 days, with long surface gravity waves not significantly present. 47 pp. Refs.

P-3496 Consideration of the Contributions of Engineering Analysis in the Study of Living Systems. E. C. DeLand. December 1966.

A symposium paper with discussion. Biological problems arising from modern research techniques are too complex to be solved without the most powerful techniques of mathematics and engineering analysis. Compared with the usual engineering problems, however, biological problems are ill-defined and immensely complex. The cooperation of specialists from each side is required. A problem in fetal blood flow, from the work of Professor George Bekey of USC, is used as illustration of the point that first-order simulations are inadequate. A biological system seems always to have closed-loop communication lines, so that a change in one variable affects every other variable. (Presented at the Symposium on the Impact of Bioengineering on Engineering Education, sponsored by Oak Ridge Associated University, August 1966.) 16 pp.

P-3518 Prelaunch Checkout in the 1970s. L. T. Mast. January 1967.

An attempt to predict the prelaunch environment of space launches in the 1970s. Increasingly complex vehicles will use built-in test equipment and an onboard computer to control and evaluate the confidence test data. More elaborate ground computer complexes are envisioned to aid the checkout process. By 1970, essentially all of the confidence testing may well be automated. The extensive use of special-purpose display and test equipment and complex cabling is expected to shift gradually to a greater use of digital computers and CRTs with greatly enhanced capability. Closer interconnection of all computing equipment is anticipated, and more extensive closed-circuit display and data links to vehicle design centers appear likely. Through the use of increased analytic capability and simulation, partially automated fault isolation—perhaps up to 70 percent—will probably be implemented. By 1975, automated fault isolation may reach 95 percent. 9 pp. Refs.

P-3528 A General Building Block for Direct Modeling. N. B. Reilly. April 1967.

A discussion of criteria for and applications of a proposed general-purpose logical building block useful in constructing models for a variety of problem areas. The logical properties of such a device (realized through computer hardware or software) should be sufficiently complex that relatively few would be needed in model construction and sufficiently basic to provide general-purpose capability. It should be concept-oriented rather than problem-oriented and therefore more representative of the organization of conceptions of information flow in observed processes than are assembly-language commands or finite automata based on physiological principles. The building-block approach to modeling yields a number of advantages derived from enhancement of intuitive interaction, bypassing of certain mathematical difficulties, and minimizing of interruption of an investigator's thought processes. 43 pp. Refs.

P-3599 Computer Simulation Programming Languages: Perspective and Prognosis. P. J. Kiviat. September 1967.

An overview of the languages devised especially for programming computer simulations developed since 1959. Some are based on transaction flows (GPSS), others on cause-and-effect relationships expressed in events (SIMSCRIPT), activities (CSL), or processes (SIMULA). Other principal differences are static or dynamic storage allocation, levels of indirect referencing, and ability to form complex data structures. Languages may be executed interpretively by a control program (GPSS), may be direct extensions of general-purpose compilers (SIMULA of ALGOL), source languages to compilers (early SIMSCRIPT and CSL, GASP, and FORSIM IV to FORTRAN) or compile directly into assembly code (SIMSCRIPT 1.5, Extended CSL, CSL-2). The trend is away from terseness toward readability and descriptive power. 22 pp. Refs.

P-3606 Use of Multiple On-Line, Time-Shared Computer Consoles in Simulation and Gaming. G. M. Northrop. June 1967.

A progress report on the interactive use of on-line time-shared JOSS computer consoles in war gaming at RAND during the six months since publicly accessible files were added to JOSS capabilities. By programming consoles to interrogate certain files periodically, a crude but highly serviceable real-time store-and-forward communication system is created. The simple JOSS programming language is perhaps the most important feature, since it makes it possible for game players to contribute to the improvement of programming. When the automated Tactical Air Control System simulation was exercised by five Army ROTC students, the Litton Digital Message Entry Device (DMED) format proved too rigid to cover all FAC information needed, and that the Fighter Duty Officer needs three CRT displays: for FAC requests, aircraft status, and his own assignments of aircraft to missions. A text-only diplomatic message simulation and a dataonly sub-launched missile duel are also included. Teletype consoles (Type 33 and 35) can be used as JOSS consoles, permitting participation, regardless of location, through conventional teletype or dataphone connections. 66 pp. Refs.

P-3608 Statistical Considerations in Computer Simulation Experiments. G. S. Fishman. May 1967.

A tutorial given at a symposium on the interface between computer science and statistics sponsored by UCLA Extension, The American Statistical Association (Southern California Chapter), and the Association for Computing Machinery (Los Angeles Chapter), February 1, 1967. This Paper describes some fundamental statistical problems that should be recognized at all stages of a system simulation that is, or contains, a queueing network, such as inventory models and job shop manufacturing facilities. Such a simulation is the generation of stochastic processes by Monte Carlo methods. While simulation languages such as SIMSCRIPT and GPSS have been developed and refined during the past decade, very little work has been done in applying statistical methodology to the analysis of computer simulations. 7 pp. Refs. (See also RM-4880-PR, RM-5288-PR.)

P-3659 Comentarios Acerca del Uso de la Computadora en la Investigacion del Sistema Nervioso. D. H. Perkel. Diciembre 1967.

Transcript of an address in Spanish before the symposium on Computacion en el Sistema Nervioso, VIII Congreso de la Asociacion Latinoamericana de Ciencias Fisiologicas, Mexico, D.F., 1967. Four levels of the use of the computer in investigating the nervous system are distinguished: (1) as a data-reduction device; (2) as a participant in neurophysiological or behavior experiments (e.g., in on-line control of stimulus presentations); (3) as a vehicle for realizing and observing models of neural action and interaction; and (4) as a model itself for interpreting nervous system operation. The author points out that the use of the computer is a natural extension of other tools and logical methods of accepted use in neurophysiology; he warns of facile comparisons between the human brain and the computer. 6 pp.

P-3672 Input-Output Relations for Axo-Somatic Activation in a Neuron Model. R. J. MacGregor. November 1967.

Experimental findings have suggested that axo-dendritic activation is the primary source of nonlinear integration among input pulses, while axo-somatic activation mediates a relatively inflexible driving action on the cell. A theoretical basis for this distinction was previously examined and a model was presented to account for the nonlinear properties of axo-dendritic activation. The present study addresses the properties of axo-somatic activation with a digital computer simulation of the elicitation of spikes by postsynaptic potentials. Input-output relations for regular and irregular temporal patterns of excitatory activation, and for combined excitatory and inhibitory activation, are presented. The results corroborate the hypothesis. 28 pp. Refs. (See also RM-4877-ARPA.)

P-3734 Computer Simulation in Urban Research. J. P. Crecine. November 1967.

Restricting the term computer simulation to models which are surrogates for realworld urban processes, this Paper discusses those developed for use in two major areas of emerging research: (1) urban growth, development, and spatial location; (2) local government decisionmaking. It also considers two hybrid efforts aimed at simulating a synthesis of economic, political, and administrative elements of an urban system. The future in the area of decisionmaking appears bright, since progress is being made in the technology for translating abstract ideas, concepts, and symbols into computer language. In the area of urban research, however, a lack of data is limiting development. 27 pp.

P-3747 A Model for Continuous Neuroelectric Activity: The Encoding of Stimulus Intensity. R. J. MacGregor. February 1968.

This study applies the idea of largeamplitude depolarizations in dendritic regions to the intensity dependence of graded potentials in the vertebrate retina. The model assumes that membrane in dendritic regions of primary afferents is linear, that receptors excite primary afferents by a synaptic mechanism that is continuously active during stimulation, and that the magnitude of the permeability change depends linearly on stimulus intensity. Comparison of the results with electrical data suggests that such a synaptic mechanism might represent the source of logarithmic intensity encoding. Psychological intensity data and possible applicability to other sensory modes are briefly discussed. 36 pp. Refs.

P-3785 Another View of Transport System Analysis. M. Wohl. February 1968.

This Paper, which will be published in the Special Issue of the Proceedings of the Ieee on Transportation, examines the components and interworkings of transport systems and indicates some directions for improving our analysis capability. Suggestions are made for designing more realistic models for determining demand for travel, one of the major weaknesses of current efforts, and for improving methods of measuring the performance of a system. Much remains to be done in terms of modification, amplification, and clarification before we will be in a position to embark on large-scale systems studies or projects. 47 pp.

P-3818 Simulation Techniques for Analyzing Air Combat Systems. T. E. Greene, J. H. Huntzicker. May 1968.

A description of analytical aids devised to assist in solving the problems encountered in designing air-to-air fighter systems. TACTICS, the RAND computer model for analysis of air combat systems, is designed for dynamic simulation of maneuvering flight. Aerodynamic and propulsion performance of each of three maneuvering bodies is represented for three-dimensional flights and for pitch, roll, and yaw altitudes, giving six-degrees-of-freedom motion. Aircraft and missile performance data can be input in the form of tables or analytical expressions. The output is of two kinds: tabular data and graphical display. The graphical display assists the analyst in visualizing the combat action that has been simulated; the tabular output data are more significant for purposes of analysis. 20 pp. Refs.

P-3838 GRAIL/GPSS: Graphic On-Line Modeling. J. P. Haverty. June 1968.

A status report on the RAND-developed capability for interactive modeling of dynamic systems using the GPSS flowcharting technique on the GRAIL (Graphical Input Language) facilities. Analysts are dissatisfied with the long lead time required to translate a proposed simulation from a logical flow diagram to a detailed set of computer instructions to be keypunched. These steps can be bypassed by working at a GRAIL console, drawing on the RAND Tablet and having the symbols recognized

and displayed by the character recognition program. Using the GRAIL/GPSS system increases the analyst's efficiency tenfold to a hundredfold. GRAIL capabilities not yet incorporated include shrinking, enlarging, and moving geometric figures, and monitoring on-line execution of the flow diagram. (Presented at an IBM Seminar on Operations Research in the Aerospace Industry: Models in Planning and Control, Newport Beach, April 1968.) 14 pp. Refs.

P-3860 Credit Expansion in a Multibank System. I. N. Fisher. June 1968.

This Paper presents a model of the banking system that relates system credit expansion to individual bank borrowing and lending decisions. The results of the computer simulation based on the model demonstrate that expectations in the credit expansion process can influence the speed of system deposit expansion— optimism leading to considerably more rapid credit expansion than pessimism. Consequently, statements and action calculated to shift expectations in the appropriate direction may sharpen the effectiveness of various Federal Reserve policies in controlling the total volume of credit. Also, system deposits increase more rapidly when new reserves are introduced throughout the system; therefore, the effectiveness of monetary policy may be improved significantly by decentralizing the Federal Reserve's open market operation. The model's primary advantage is that it illustrates explicitly the connection between system behavior and individual bank lending and borrowing decisions, so that the effects of such factors as bank expectations and uncertainty on system behavior may be predicted. The model may thus provide a more effective means for evaluating alternative Federal Reserve policies. 21 pp.

P-3861 Simulation Programming Using SIMSCRIPT II. P. J. Kiviat. September 1968.

Description of a computer simulation of production and sales, designed to illustrate as many as possible of the programming features of SIMSCRIPT II in a natural, problem-oriented setting. The Paper describes the system to be modeled; outlines problems the model is designed to study (namely, to determine the number of machines needed to provide adequate customer service); lists the complete SIMSCRIPT simulation program, well annotated; and gives a set of typical data cards. The last section works through the program in some detail, explaining the syntax and semantics of the statements. 22 pp.

P-3877 New Directions for Passenger Demand Analysis and Forecasting. G. Kraft, M. Wohl. June 1968.

A discussion of the significant issues involved in developing a model that will help to evaluate alternative transport programs in terms of the changes they may evoke or to justify a program on the basis of reliable forecasts of the values associated with the project. The demand model described, incorporating direct and cross-elasticities, permits both the total amount of tripmaking and the split among modes to be altered as the trip price or travel time for any mode is changed, and treats trip decisions as simultaneous and interrelated. A satisfactory model must also recognize that travel decisions are derived from a large number of socioeconomic factors and that there are a relatively large number of alternatives available to the traveler in terms of purpose, mode, time, route, price, etc. In addition, for forecasting purposes, the model must interrelate demand and price/performance functions and recognize the interaction between the increase in tripmaking as service improves and the build-up of congestion and reduction in service as the volume increases. Lastly, the long-term influence of changes in transportation facilities on social and economic development in an urban area should not be ignored. More intensive effort in data collection in this area is required. 61 pp.

P-3942 Fighter Aircraft Performance Modeling, Simulation, and Flight Testing for Research and Development. T. E. Greene, R. L. Spicer. November 1968.

A comparison of the effectiveness of current methods which measure fighter aircraft system performance. Involving various degrees of simulation, the techniques are: (1) modeling (usage of computer programs to calculate aircraft and/ or missile flight paths); (2) simulation (usage of one or more pilots on line with a computer and display system, flying simulated aircraft in real time); and (3) flight testing (usage of actual aircraft and hardware in simulated combat operations). The techniques are reviewed as to degree of experimental control, ease of variation of parameters, range of parameter variability, cost and time required per case, realism and credibility. Modeling and simulation are useful to RD decisionmaking, but must eventually be set aside in favor of experimental and demonstration testing of hardware. However, all three techniques can interact effectively in research programs. 19 pp. Refs. (EB)

P-3977 GAPSS (Graphical Analysis Procedures for System Simulation). T. E. Bell. January 1969.

A discussion of two types of computer graphics displays used to analyze data following simulations done in the GPSS language. The results showed that the hybrid display showing changes over time (and utilizing a Gantt chart) was superior to the display sequentially presenting individual states of a system. Additional general conclusions are that (1) an analyst almost never views simulation data the right way on the first try; (2) computer graphics helps an analyst identify relationships obscured by summary statistics; (3) computer graphics displays should be tested for usefulness by the people for whom they are designed— intuitive feelings are often wrong. 13 pp. Refs. (MJP)

P-4000-1 Managing Climatic Resources. J. O. Fletcher. March 1969.

Only in the last century have we begun to observe the global ocean/atmosphere system in enough detail to discern the geographical patterns of climatic change. Man is undoubtedly influencing the global climate; certainly several products of his activity (smog, dust, and heat pollution) will be more influential in a few decades, if they are not controlled. Specific cause and effect estimates are still very uncertain in this respect. On the other hand, it does appear to be within man's engineering capacity to influence the global system by altering patterns of thermal forcing. There have been specific proposals made for improving climatic resources of particular regions. Viewing the results of computer technology and simulation models used thus far in weather modification studies, it is significant that we are reaching, or perhaps have already reached, a technological threshold from which progress can be proportional to the investment of effort. 27 pp. Refs. (KB)

P-4017 A Note on Handling Uncertainty in Force-Structure Studies. D. E. Emerson. February 1969.

The description of preliminary work on a model designed to estimate the U.S. assured destruction capability for specified U.S. and Soviet Union postures. There is no optimization of force mix or balancing of defenses internal to the model. The model is deterministic: Input factors are selected from specified distributions and then all phases of the two-strike campaign are approximated by means of expected-value submodels. The future best estimate for each planning factor is determined by a sample drawn from the distribution of current uncertainty. The approach can provide useful insights for the decisionmaker. Based on specified degrees of uncertainty in the several inputs, it is possible to determine the appropriate force mix (or size) to achieve a desired level of confidence at least cost. 9 pp. (KB)

P-4019 Computers and the Delivery of Medical Care. E. C. DeLand, W. F. Raub, R. W. Stacy, B. D. Waxman. February 1969.

The Introduction to Computers in Biomedical Research, Vol. III, evaluating accomplishments over a 3-year period and predicting areas for future emphasis. Characteristics distinguishing recent computer systems from those in the past include increased complexity, flexibility, and capacity for improving health-care services. Work is being done to implement present image processing techniques and, in addition, to promote computer-aided instruction in regard to biomedicine. In the future, mathematical models combined with graphic and flexible forms of data presentation could become an integral part of research hospitals, monitored patient wards and clinics, and basic research laboratories. Interactive computer terminals and the attendant central processor software will be useful for hospital communications, for model building and hypothesis testing, for patient autointerview, for perusing files of data and for other tasks requiring the transfer or analysis of data. 20 pp. (KB)

P-4027 Weather Modification Research– A Desire and an Approach. S. M. Greenfield. February 1969.

A discussion emphasizing the importance of understanding the atmospheric environment in depth as a prime requisite for weather modification. Largely by the impetus of Langmuir's research on the use of ice crystals in precipitation studies, the public has shown interest in rainmaking and cloud seeding activities during the past two decades. In the early '60's two major research documents pointed the way to the use of computers for numerically modeling the atmosphere. With the space age, essentially simultaneous observation of atmospheric parameters has been possible on a global level. More important, perhaps, is that these studies point out the danger that exists in attempts to modify large-scale weather phenomena without sufficient understanding of the possible results. The latter half of the report investigates the nature of the weather modification problem diagramatically. 15 pp. (KB)

P-4038 A Proposed Scheme for Federal Support for Education. J. E. Bruno. February 1969.

This Paper develops a linear programming model for calculating the amount of federal funds for education to be distributed to each state. Federal aid to education will probably expand into a general program of grants to support equalization of educational opportunity among the states. The proposed model is a step toward rational and systematic resource allocation. It takes into account the political, economic, and social constraints affecting federal resources and federal-state relationships and includes a correction factor which adjusts a state's educational expenditure to its fiscal ability. The prototype model may be made more complex as application in an actual situation reveals additional constraints and factors. 29 pp. Refs. (CD)

P-4070 Pilot Training Study. W. E. Mooz. April 1969.

Description of some of the results of Rand's Pilot Training Study, an analysis of the USAF pilot training process in terms of costs and required resources. The study has developed two types of computer simulation models—PILOT, a decision model, and a parametric resource and cost model—to aid in broad planning for pilot training over the next 20 years. They permit analysis of individual training operations with regard to syllabi, course lengths, production capacity, resources necessary, and course costs. In addition, the pilot training process can be analyzed in terms of the factors that cause the need for pilots: policy variables relating to course size, rotation of pilots for career development, pilot loss rates, and cross-training for several aircraft. 20 pp. (CD)

P-4140 A General Simulation Model for Information Systems: A Report on a Modelling Concept. A. L. Buchanan, R. B. Waina. July 1969.

A conference paper describing a flexible, context-free information network simulation model that has been written in SIM-SCRIPT 1.5 for use by designers of large management information systems. The new model avoids the need to develop equations and to make assumptions about hard-toestimate quantitative flows; instead it is based on the individual message (or job or other temporary entity). System relationships are described in terms of how the units are tied together by message input and output. Central switching networks, single-string networks, and virtually any unconstrained network can be modeled quickly and easily by use of the program generator forms provided. The model collects standard queueing statistics and measures system response also in terms of the total flow time of sequences of messages. 17 pp. (MW)

P-4152 Simulation in Field Testing. C. C. Lovell. August 1969.

An argument for the use of near-realtime computer simulation as an ongoing analytical aid in operational field testing. Test-oriented simulations provide a unique capability for filling in the inevitable gaps in the data, for detecting the most fruitful lines of testing to pursue, for continuing under circumstances that preclude further physical testing, and for reproducing uncapturable conditions for analysis. Specific examples are the RAPID ROGER study of squadron sortie rates achievable in SEA, and a study of proposed V/STOL operations using F-100Ds in the role of V/STOL airframes not yet built. The computer simulation part of the V/STOL test cost one man-year and $12,000 out of the total half-million, yet reduced needed testing by two-fifths. 13 pp. Refs. (MW)

P-4163 Environmental Simulation Tool in a Marine Waste Disposal Study of Jamaica Bay. J. J. Leendertse. March 1970.

Description of a model of fluid waste discharges in an estuary involving relationships between the waste load, the location of discharges, the degree of treatment, the geometry of the estuary, the flow in the estuary, and the temperature. Since present computational techniques are inadequate to deal with the three-dimensional computations of fluid flow and the complicated boundaries of estuaries, vertical integration of the equation of motion and continuity is used to reduce the problem to a two-dimensional one. The discrete values of the variables are described on a grid, using a space-staggered scheme, in which water levels and velocities are described at different grid points. Since mass densities are described at the same location as the water levels, there exists in the formula, operated upon in time, a centrally located spatial derivative for the linear term. Water levels and mass densities are computed on graphical displays of the outline of the bay with grid points. 12 pp. Ref. (See also RM-6230, D-20024.) (MT)

P-4173 Trends in Military Gaming. M. G. Weiner. August 1969.

Traditionally limited to war, gaming is now applied to business, urban, social, and other areas. Since all deal with confrontation between protagonists, confrontation analysis may be the appropriate term, with military gaming a branch concerned with military problems. Military gaming—from guerrilla to space warfare—is still modeled on World War II combat operations, with little attempt to introduce the nontechnical aspects. Computers have expanded gaming chronologically, geographically, and technically, standardizing inputs and simulation programs. Emphasis is not only on the model as a simulation tool, but also on the development of the micromodel, reaching toward the goal of variable resolution– i.e., gaming simultaneously at the lowest and highest level using submodels operated through an executive routine. Another trend moves away from outcomes toward performance-oriented gaming; as the measure of effectiveness under certain conditions gaming becomes a research tool rather than a training tool. 7 pp. (SM)

P-4226 Formation of Planetary Systems by Aggregation: A Computer Simulation. S. H. Dole. October 1969.

Planetary systems that display the major regularities and irregularities of the solar system have been produced in a series of computer experiments employing a Monte Carlo technique. It is hypothesized that stars and planets form within cold, dark globules of dust and gas through aggregation of grains and inelastic collisions of particles. A computer program simulates the processes by which planets grow in accordance with this hypothesis from preplanetary nuclei on random orbits within the cloud of dust and gas surrounding a newly formed star. Each planetary system generated by using a different series of random numbers inputs is unique, but in all cases the orbital spacings have patterns of regularity suggestive of Bode's law, and the planetary mass distributions are similar to the solar system's. Binary star systems are produced in the same program by increasing the value of one parameter, the coefficient of density in the cloud. 45 pp. Refs. (Author)

P-4315 Atmospheric Modeling, Field Programs, and Decision Systems. F. W. Murray. March 1970.

The interrelation between field programs and atmospheric modeling is discussed in the context of studies of weather modification. In particular, numerical models of convective clouds are considered. It is shown how activities in both field programs and modeling affect decisions concerning each other, culminating in the use of models for day-to-day go and no go decisions concerning the field programs. Illustrations are given from work done at Rand and elsewhere. A few typical results from the Rand cumulus dynamics model are presented. This talk was prepared for the 6th Skywater Conference, sponsored by the Bureau of Reclamation in Denver, 10-11 February 1970. 15 pp. Ref. (Author)

P-4390 Prevention of Hypokalemic Cardiac Arrhythmias Associated with Cardiopulmonary Bypass and Hemodilution. E. C. DeLand, R. P. Henney, T. A. Riemenschneider, J. V. Maloney. December 1970.

An application of the Rand computer model of fluid balance and electrolyte distribution in the human body (RM-4347) to solve a common

problem of open-heart surgery: depletion of potassium in the blood serum interfering with the normal heartbeat. This potassium loss, or hypokalemia, has been attributed to preoperative diuretic therapy, digitalis, and hemodilution. The effects of extracorporeal hemodilution circulation, involving an extremely complex set of chemical thermodynamic relationships, were simulated, and the results checked against experiments with 16 dogs and observations of 5 patients undergoing heart-lung bypass. Hypokalemia is not prevented by simply adding potassium ion to the hemodiluent, nor by adding protein, but is prevented by adding both. (Presented at the Surgical Forum session of the American College of Surgeons, October 1970; to be published in Surgical Forum. 4 pp. Ref. (MW)

P-4410 Modeling Continuous Systems with BIOMOD—A Preliminary Report. R. Clark, G. F. Groner, R. A. Berman. August 1970.

Models a fluid reservoir system using the current version of BIOMOD, and interactive computer-graphics system for biological modeling. The BIOMOD system features interaction with immediate feedback, hierarchical model structuring, and user-oriented model-definition languages. It operates on an interactive graphics console comprising a CRT screen, a RAND Tablet, and a keyboard. The user may draw block diagrams, handprint or type text, push displayed buttons to initiate certain actions, and drag labels. He may represent a model by a block diagram, each component of which may be defined by another block diagram. This facilitates devising complex models one portion at a time. When BIOMOD is completed, the user may define model components by chemical equations, differential equations, or data curves, rather than having to translate his model description into a conventional simulation language. During model simulation, the user may display curves for different variables, change scales, or alter simulation parameters. 41 pp. Ref. (LC)

P-4446 Evaluation and Innovation in Urban Research. G. D. Brewer. August 1970.

Analyzes the methodology of computer simulation in the social sciences and its ability to manage complexly organized systems. The in principle arguments advanced in support of the method have been insufficiently tempered by honest appraisal of past in practice experiences. A continuation of the existing trends could harm both the method and the processes of problemsolving in a social context. An initial problem is the development of an appraisal function—i.e., a series of questions or criteria against which a computer simulation may be judged. The experiences from 2 empirical contexts are related in efforts to construct a socalled policy-assisting class of simulation models. Deficiencies in the appraisal included the vastly different orientations of participants interviewed, salesmanship, and various technical and theoretical shortcomings. 47 pp. (KB)

P-4454 A Model of Global Climate and Ecology. W. R. Graham, M. Warshaw. September 1970.

Conceptual design for a model simulating the interaction of the physical world and the biosphere with man's activities and the climate, defined as that part of the prevailing conditions that affect life both directly and indirectly. It must integrate what is know in many diverse fields, plus much not yet known, into a single, self-consistent, tractable computational problem. Where analysis or observation fails, the modeler must use a range of relationships that must then await future observations for their definition. A 12-stage long-term sequence of model construction gives for each stage the problem to be solved, the action, and the result. 20 pp. Ref. (MW)

P-4476 Climate Modification and National Security. R. R. Rapp. October 1970.

The Rand program on climate dynamics for environmental security begins with the concept that the U.S. might be harmed either inadvertently or maliciously by changes in the climate elsewhere on the globe. The program to develop a methodology to anticipate climatic changes has been in progress at Rand for about a year, and includes 9 subprojects: (1) determination of changes in the mean state of an atmospheric model with different boundary conditions and different initial conditions, (2) experiments with the Mintz-Arakawa model to determine the direction of change, (3) experiments with a newly developed barotropic ocean model, (4) a study of the effect of turbidity and cloudiness on atmospheric radiation, (5) development of a small-scale convective cloud model, (6) establishment of new numerical analysis methods, (7) comparison of the present model with alternative models, (8) continuation of the study of climate as it has been recorded or deduced in the past, and (9) preparation of the ILLIAC IV to program cloud models in the future. 9 pp. Ref. (KB)

P-4486 A Stochastic Network Approach to Test and Checkout. L. J. Watters, M. V. Vasilik. October 1970.

Demonstrates the usefulness of GERT simulation for modeling and evaluating policies and processes in the area of test and checkout (see GERT: Graphical Analysis and Review Technique, RM-4973). Some of the latest developments and extensions to a GERT simulation program are employed to model a test plan development process, a general test and checkout process, and specific cases of the latter. (Presented at the Fourth Conference on Applications of Simulation, sponsored by AIIE, ACM, IEEE, SHARE, SCI, and TIMS, in New York, December 1970.) 31 pp. Ref. (Author)

P-4503 Interactive Simulation of Continuous Systems: Progress and Prospects. G. A. Bekey, E. C. DeLand. January 1971.

The development of a simulation system that would provide both the interactive, user-oriented features of analog computers and the precision, memory, and computing power of the digital computer has been a design objective for many years. This paper reviews the background of present-day continuous systems simulation techniques, with emphasis on interactive, graphicoriented systems. The state of the art is discussed, particularly as it concerns user convenience, interactive features, the use of block diagram descriptions, and graphic displays. BIOMOD, a system recently developed for simulation of biological systems, is used as an example. Limitations of present-day systems and prospects for near-future development are discussed. 21 pp. Ref. (Author)

COMPUTER SIMULATION ORDER FORM

(Please Print)

Name: _____

Address: _____

_____

_____

TOTAL COST: $ _____

California residents add 5% sales tax: _____

TOTAL AMOUNT ENCLOSED: $ _____

TO: Communications Department
The Rand Corporation
1700 Main Street
Santa Monica, California 90406

DATE: _____

QUANTITY	PUBLICATION	COST	TOTAL COST	QUANTITY	PUBLICATION	COST	TOTAL COST	QUANTITY	PUBLICATION	COST	TOTAL COST
	R-495-PR	$5.00			RM-4782-PR	$2.00			RM-5370-PR	$2.00	
	R-505-ARPA	2.00			RM-4816-PR	4.00			RM-5376-PR	3.00	
	R-514-PR	4.00			RM-4833-NIH	2.00			RM-5378-PR	3.00	
	R-560-NASA/PR	2.00			RM-4880-PR	2.00			RM-5379-1-NASA	3.00	
	R-585-PR	4.00			RM-4923-PR	5.00			RM-5387-PR	2.00	
	R-632-NYC	2.00			RM-4939-PR	2.00			RM-5392-PR	3.00	
	R-641-PR	3.00			RM-4945-PR	2.00			RM-5396-PR	4.00	
	R-642-RC	2.00			RM-4950-PR	2.00			RM-5404-PR	4.00	
	RM-4219-ISA (Abr.)	3.00			RM-4962-PR	4.00			RM-5426-PR	3.00	
	RM-4242-PR	3.00			RM-5005-NASA	2.00			RM-5451-PR	3.00	
	RM-4347-PR	4.00			RM-5110-NASA	3.00			RM-5517-ISA	3.00	
	RM-4393-PR	3.00			RM-5129-PR	4.00			RM-5519-1-PR	4.00	
	RM-4406-NIH	3.00			RM-5145-PR	2.00			RM-5540-PR	2.00	
	RM-4460-PR	2.00			RM-5153-ARPA	2.00			RM-5544-PR	4.00	
	RM-4579-NIH	3.00			RM-5162-PR	4.00			RM-5553-NSF	3.00	
	RM-4589-PR	2.00			RM-5183-PR	3.00			RM-5564-NRL	2.00	
	RM-4659-PR	5.00			RM-5235-PR	5.00			RM-5582-ESSA	2.00	
	RM-4660-PR	4.00			RM-5244-PR	3.00			RM-5582/1-ESSA	1.00	
	RM-4661-PR	4.00			RM-5262-PR	3.00			RM-5598-RC	2.00	
	RM-4662-PR	5.00			RM-5272-PR	2.00			RM-5691-PR	4.00	
	RM-4663-PR	5.00			RM-5288-1-PR	2.00			RM-5722-PR	2.00	
	RM-4716-NIH	2.00			RM-5294-PR	4.00			RM-5759-PR	4.00	

(over)

QUANTITY	PUBLICATION	COST	TOTAL COST	QUANTITY	PUBLICATION	COST	TOTAL COST	QUANTITY	PUBLICATION	COST	TOTAL COST
	RM-5769-PR	$4.00			RM-6211-ARPA	$3.00			P-3606	$3.00	
	RM-5777-PR	3.00			RM-6214-NIH	3.00			P-3608	.50	
	RM-5809-NIH	3.00			RM-6224-PR	3.00			P-3659	.50	
	RM-5810-PR	3.00			RM-6230-RC	3.00			P-3672	2.00	
	RM-5821-PR	3.00			RM-6256-PR	3.00			P-3734	2.00	
	RM-5822-PR	3.00			RM-6268-PR	3.00			P-3747	2.00	
	RM-5829-PR	3.00			RM-6279-PR	4.00			P-3785	2.00	
	RM-5859-PR	4.00			RM-6327-NIH	2.00			P-3818	1.00	
	RM-5866-PR	3.00			RM-6357-PR	2.00			P-3838	1.00	
	RM-5870-ESSA	2.00			P-3036	2.00			P-3860	1.00	
	RM-5883-PR	4.00			P-3057	1.00			P-3861	1.00	
	RM-5893-RC	3.00			P-3063	2.00			P-3877	3.00	
	RM-5925-NIH	3.00			P-3076	.50			P-3942	1.00	
	RM-5932-NRL	2.00			P-3114	2.00			P-3977	1.00	
	RM-5937-PR	2.00			P-3128	1.00			P-4000-1	2.00	
	RM-5940-PR	3.00			P-3141	.50			P-4017	.50	
	RM-5949-PR	4.00			P-3148	1.00			P-4019	1.00	
	RM-5955-NIH	2.00			P-3194	2.00			P-4027	1.00	
	RM-6036-PR	2.00			P-3198	2.00			P-4038	2.00	
	RM-6049-PR	3.00			P-3214	1.00			P-4070	1.00	
	RM-6073-PR	3.00			P-3254	4.00			P-4140	1.00	
	RM-6081-PR	3.00			P-3301	1.00			P-4152	1.00	
	RM-6082-PR	3.00			P-3314	.50			P-4163	.50	
	RM-6083-PR	4.00			P-3329	1.00			P-4173	.50	
	RM-6084-PR	5.00			P-3348	1.00			P-4226	2.00	
	RM-6085-PR	3.00			P-3349	1.00			P-4315	1.00	
	RM-6086-PR	3.00			P-3400	1.00			P-4390	.50	
	RM-6087-PR	3.00			P-3453	1.00			P-4410	2.00	
	RM-6093-PR	4.00			P-3455-1	2.00			P-4446	2.00	
	RM-6110-RC	3.00			P-3496	1.00			P-4454	1.00	
	RM-6112-PR	2.00			P-3518	.50			P-4476	.50	
	RM-6132-NASA	3.00			P-3528	2.00			P-4486	2.00	
	RM-6203-PR	2.00			P-3599	1.00			P-4503	1.00	
	RM-6210-ARPA	1.00									